Spatio-temporal associations with memory cues are linked to analogue traumatic intrusions

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Abstract

Trauma survivors with post-traumatic stress disorder (PTSD) frequently experience intrusive trauma memories associated with a feeling of "nowness". Information-processing models of PTSD ascribe these symptoms to an insufficient integration of memories with their spatio-temporal context in the past, turning them into powerful stressors. Here, we tested the idea that automatic associations of trauma reminders with the present or the past predict intrusive memories. We instructed 96 healthy participants to view two different traumatic films. Participants then underwent a computerized training that established implicit contingencies between film reminder pictures with the verbal responses "now" or "past" to increase and reduce intrusions, respectively. The training successfully altered implicit spatio-temporal associations for film reminder stimuli on a subsequent Implicit Association Test (IAT). There were no additional transfer effects for tense usage during a free recall task after one week and for the development of intrusion symptoms (one-week diary, retrospective questionnaire). However, participants who associated one film more strongly with the present and the other with the past consistently reported relatively more intrusive memories related to the former film. Thus, our results lend support to information processing models of PTSD and warrant further investigation of the causal role of implicit associations with spatio-temporal information.

Key words: Implicit associations; trauma film paradigm; cognitive bias modification; temporal associations; PTSD; Affective Simon Task-Training

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Most survivors of psychological trauma experience recurrent aversive memories in the form of vivid images that suddenly intrude into consciousness. While intrusive trauma memories can be highly distressing, they typically fade with time and do not lead to prolonged functional impairment (Bonanno & Mancini, 2008). However, in severe cases, intrusions and flashbacks can become persistent and debilitating, forming the core feature of post-traumatic stress disorder (PTSD; American Psychiatric Association, 2013). It has been suggested that the development of this disorder results from cognitive aberrations during memory encoding, consolidation, and/or retrieval (Brewin, Dalgleish, & Joseph, 1996; Ehlers & Clark, 2000; Rubin, Berntsen, & Bohni, 2008). Indeed, emerging evidence suggests that PTSD symptoms can be linked to a heightened attentional preference for trauma- or general-threat related stimuli, or to biased interpretations of ambiguous situations as negative or threatening (Koster, Fox, & MacLeod, 2009; Woud, Verwoerd, & Krans, 2017). However, the mechanisms underlying the development of trauma memories that are overly accessible, intrusive, and persistent, remain ill-understood.

A characteristic observation in PTSD patients is that their most distressing memories tend to entail a strong sense of reliving (Birrer, Michael, & Munsch, 2007; Michael, Ehlers, Halligan, & Clark, 2005). That is, survivors with PTSD often report sensory-rich memories that feel as if the traumatic events were happening again *here and now* – rather than as being a recollection of the past. Such a subjective sense of immersion or “nowness” can turn memories into powerful stressors. For instance, it may impede the trauma survivor from distinguishing currently safe environments from threatening past ones, resulting in emotional responses that are similar to the original trauma. This may suggest that trauma memories become especially intrusive and recurrent when they lack an automatic association with the appropriate temporal and spatial information. Therefore, this study examines whether automatic associations with time and space are positively correlated with the development of intrusive memories.

Information processing models of PTSD posit that intrusive memories with a sense of nowness result from trauma representations that are overly accessible, insufficiently processed, and strongly associated with negative appraisals (Brewin, Gregory, Lipton, & Burgess, 2010; Ehlers & Clark, 2000; Foa, Steketee, & Rothbaum, 1989; Resick & Schnicke, 1992). Accordingly, perceptual elements of the traumatic experience may be represented in an excessive fear structure (i.e., along with fear-related response and interpretation patterns; Foa et al., 1989), at the expense of more abstract, elaborated, and contextualized representations (Brewin et al., 2010). Furthermore, due to a poor integration of distressing elements within autobiographical memory, trauma memories may be excessively easy to trigger by environmental cues with even vague sensory similarity to the traumatic event (Ehlers & Clark, 2000). Involuntary memories of this kind are thought to rely on limited capacity resources that operate automatically and fast (Baddeley & Andrade, 2000; Krans, Näring, Holmes, & Becker, 2010; May, Andrade, Panabokke, & Kavanagh, 2010). For instance, they can be distinguished from deliberate processes under more explicit cognitive control (Kahneman, 2012), including voluntary memories (e.g., Conway & Pleydell-Pearce, 2000). Taken together, theoretical models suggest that in individuals with PTSD, trauma-related stimuli can trigger involuntary memories that are isolated from relevant contextual information and automatically co-activate threat-related appraisals and behavioural response schemata. As a result, trauma survivors with PTSD may re-experience the traumatic events as comprising of immediate threat to their current well-being.

Several lines of research lend support to these propositions, with evidence showing that emotional arousal and acute stress impair the integration of temporal and spatial context information in memory. For instance, emotional arousal has been linked to poorer learning of associations between objects and their surrounding context (Bisby & Burgess, 2014; Bisby, Horner, Bush, & Burgess, 2018) and with poorer memory of temporal sequences, particularly when individuals feel anxious (Huntjens, Wessel, Postma, van Wees-Cieraad, & de Jong, 2015). In turn, better learning of contextual features has been associated with fewer PTSD symptoms in analogue and clinical studies (Meyer, Krans, van Ast, & Smeets, 2017; Meyer et al., 2013; Smith, Burgess, Brewin, & King, 2015). Moreover, PTSD patients display a marked inability to remember temporal sequence information (Zlomuzica et al., 2018), and symptom levels are associated with more frequent use of the present tense when patients are asked to write a narrative of their trauma (Crespo & Fernández-Lansac, 2016; Fernández-Lansac & Crespo, 2017). Taken together, accumulating evidence supports the key assumption that intrusive memories result from an impaired binding between memory cues and spatio-temporal information (Birrer et al., 2007; Ehlers & Clark, 2000; Rubin, Boals, & Berntsen, 2008).

In addition, numerous studies support the view that the development and maintenance of PTSD is driven by automatic information processing mechanisms that do not require explicit cognitive control. For instance, automatic attentional biases towards trauma-related stimuli may foster the development and maintenance of PTSD symptoms (Fani et al., 2012; Verwoerd, Wessel, & de Jong, 2012), while implicit tendencies to avoid trauma-relevant stimuli have been linked to exaggerated arousal and vigilance among PTSD patients (Fleurkens, Rinck, & van Minnen, 2014; Wittekind et al., 2015). Based on the evidence reviewed above, we suggest a similar role for the automatic processing of spatio-temporal information in traumatic memory. In particular, when confronted with reminder cues, individuals with PTSD might automatically tend to appraise the activated sensation-based trauma representations as a current phenomenon rather than as a past event. This automatic appraisal might be due to a strong implicit association between traumatic memory representations and the spatiotemporal present (i.e., the “here and now”) on the one hand, and to weakened access to the appropriate spatio-temporal context information (e.g., that the events took place in the past and elsewhere). Therefore, automatic associations of memory cues with the present versus the past might be direct correlates of memory intrusiveness. In contrast, trauma survivors who do not develop PTSD can be expected to associate their traumatic memories more automatically with the past rather than the present. Consequently, training trauma survivors to learn a contingency between trauma-related stimuli and the past or the present should reduce or increase intrusion development, respectively.

Current study

The present study directly tests this assumption using the trauma film paradigm (James et al., 2016) as a controlled laboratory analogue of PTSD. This approach makes it possible to investigate cognitive-affective processing of standardized trauma reminder cues (e.g., Meyer et al., 2014; Verwoerd et al., 2012). Using a counterbalanced crossover design, we exposed each participant to two distinct sets of shocking film fragments in a counterbalanced order. We then aimed to manipulate automatic associations between trauma reminder cues and temporal and spatial concepts, using an Affective Simon Task-Training (AST-T; Ikani, Becker, Tyborowska, & Rinck, 2019). For the current study, this computerized AST-T experimentally induced a contingency between pictures of one film with the verbal response “now”, and between the other film and the response “past”. Afterwards, we measured implicit associations between the pictures and word stimuli related to the past and the present using an Implicit Association Task (IAT; Greenwald, McGhee, & Schwartz, 1998) and had participants complete an involuntary memory diary. In addition, we measured intrusive memories retrospectively at one-week follow-up. Finally, participants were asked to provide a free recall of their memory of each film. This allowed us to assess on a linguistic level whether the memories tended to be narrated in the present or in the past tense, as a proxy for the associations between the memories and their spatio-temporal context.

We expected that in the AST-T, participants would learn contingencies between pictures from one trauma film with a “now” response and the other with a “past” response, which would become manifest subsequently in stronger implicit associations with the broader temporal and spatial concepts of the present and the past on the IAT. Next, we hypothesized that participants would report relatively fewer intrusive memories of the film that was associated with the “past” response during the training, and relatively more intrusions about the film that was coupled with the “now” response. In addition, we hypothesized that the learned contingencies during the AST-T would alter the quality of memories, such that free recall narratives would be characterized by more frequent use of the present or the past tense, respectively.

Method

Participants

Ninety-six healthy participants (73 women) aged between 18 and 35 years (M = 22.4, SD = 3.9) were recruited at the university campus and completed this study. One additional participant terminated the experiment prematurely and was excluded from all analyses. Participants were required to be native speakers of German and understand spoken English at intermediate or higher level. Exclusion criteria were recent psychological or psychiatric treatment, psychoactive medication, blood phobia, alcohol or drug abuse, and a history of trauma exposure. Participants were informed beforehand that the materials used in the study might be experienced as shocking and cause negative emotions. Eligibility criteria were established by means of a self-assessment checklist (yes/no questions) that was sent by email before potential inclusion. To avoid unnecessary collection of sensitive data, candidates not passing the self-assessment were instructed that they did not need to respond. Candidates with ambiguous reports were not allowed to participate. Participants gave written informed consent, and received a small monetary reward or partial course credits for completion of the study. The study was approved by the institutional ethics committee of the University of Münster.

Trauma films

We used two distinct sets of trauma film fragments, each lasting approximately 10 min. The first consisted of actual footage of the atrocities during the 1994 genocide in Rwanda, henceforth labelled “civil war” fragments. The second film depicts a staged severe road accident from a road education movie against texting while driving, hereafter labelled “car crash” fragments. Shorter versions of the same stimuli had been used as part of a trauma-film compilation in four prior studies (Meyer et al., 2017; Meyer et al., 2013; and two unpublished datasets), where these two film sets consistently produced the highest number of intrusive memories, as recorded in one-week diaries (Holmes, James, Coode-Bate, & Deeprose, 2009). In particular, in the combined sample of 398 participants, the compilation (i.e., various fragments unmatched for duration and shown in fixed order; also including graphic foot-age of different surgeries and of a person drowning) induced 5.4 intrusions (SD = 4.6), the largest proportion concerning the car crash (M = 1.8, SD = 2.6), followed by the civil war fragments (M = 1.2, SD = 2.3). Using extended versions (similar to Meyer et al., 2014) and no other fragments, we expected slightly higher numbers of intrusions for both sets in the current study. Another advantage of these two sets is that both are rich enough in detail to enable text analyses in freely recalled memories (e.g., Theunissen, Meyer, Memon, & Weinsheimer, 2017). At the same time, their content is highly unrelated, making it possible to match diary records of intrusions with certainty to one set or the other. Relatedly, memory for one film is unlikely to interfere memory formation for the other, which has been shown to occur in repeated, very similar traumatic events (Theunissen et al., 2017). Based on these considerations, we deemed these two sets of stimuli particularly well suited for a within-subject comparison of intrusive memories.

Computerized past/nowness training

In an adapted training version of the Affective Simon Task (De Houwer & Eelen, 1998) – the Affective Simon Task-Training (AST-T; Ikani et al., 2019) – participants were repeatedly trained to learn a contingency between reminder pictures from one trauma film and the verbal response “now” and between the other film and the verbal response “past”. The AST-T achieves this by requiring participants to respond to a relevant feature of the stimulus (e.g., a certain colour) whilst ignoring an irrelevant feature (i.e., the stimulus content). In this version of the AST-T, 20 screen captures taken from each trauma film served as stimuli. These pictures did not depict any graphic content, as they were intended to serve as reminder stimuli that evoke aversive memories rather than provoke distress in response to the image content. The pictures were displayed repeatedly on the computer screen, embedded either in a yellow or in a blue frame. Participants were explicitly instructed to respond as quickly and accurately as possible to the colour of the frame (i.e., the relevant feature). Counterbalanced across participants, one colour required them to say the word “now” (German = “jetzt”) towards a desktop microphone, while the other colour required the response “past” (German = “früher”). Critically, the colours were systematically paired with pictures of one film, inducing an implicit contingency of “now” responses with one film, and “past” responses with the other (counterbalanced across participants; see Figure 1).

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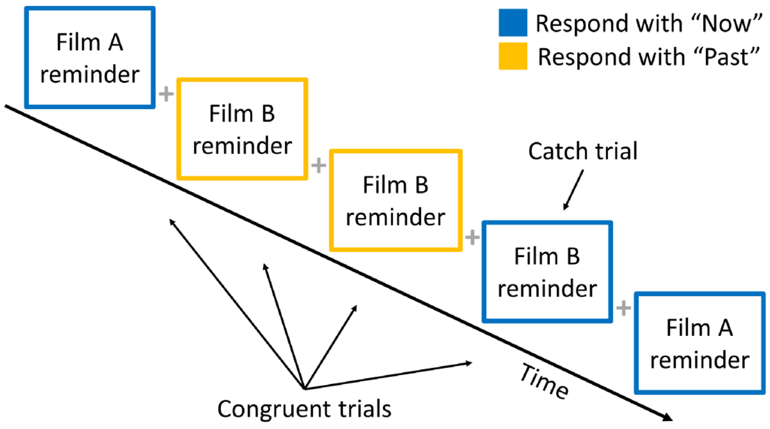

Figure 1. Schematic overview of AST-T trial types. The colour of each picture's frame indicated the required verbal response.

Following 32 practice trials, participants performed six blocks of 88 trials, 40 of which combined one colour with one film, and 40 combining the other colour with the other film (i.e., congruent trials). The remaining 8 trials in each block were inconsistent with the trained contingencies and served as catch trials (i.e., the opposite contingency of the congruent trials). Each trial lasted up to 3000 ms or until the participant responded. The task was administered with Inquisit Lab (Version 4). Voice responses were recorded using an external desktop microphone directed at the participant. Prior to the experiment, we determined a microphone distance and sensitivity levels that ensured reliable voice response detection, and kept these parameters constant for all participants. Reaction times (RT) were recorded automatically, whereas response accuracy was monitored by the experimenter. All participants were explicitly instructed to avoid or limit coughing in the direction of the microphone and to pronounce their responses clearly. When necessary, the experimenter provided feedback on the vocal responses during the training trials or in between blocks.

In order to maximize the robustness of RT analyses while preserving the ability to explore time effects, we collapsed RT data across three pairs of blocks, resulting in a sequence of three epochs with 176 trials each (Ikani et al., 2019). After excluding single trials in which RT deviated more than 3 *SD* from the individual's overall mean, as well as trials with an incorrect response, we extracted mean RT for each trial type (congruent, catch), target (film paired with now, film paired with past), and epoch.

Since RTs were linked to verbal responses, we tested for systematic differences between "now" and "past" responses in a small control experiment ($N = 18$). In particular, we administered one AST-T block (i.e., 88 trials, following 32 practice trials), with all reminder stimuli replaced by neutral images from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005; counterbalanced across participants). This revealed a systematic difference between all correct "now" ($M = 500.9$ ms, $SD = 91.3$) and "past" responses ($M = 552.9$ ms, $SD = 79.1$), $M_{Difference} = 52.0$, $SD = 34.8$, $t(17) = 6.33$, $p < .001$, $d = 1.49$, in line with differences in acoustic rise time of the two words in German (i.e., "früher" < "jetzt"). To minimize the influence of this measurement artefact on the AST-T analyses, we extracted each participant's mean score per verbal response (i.e., across congruent and catch trials) and subtracted it from the means for each trial type, target, and epoch, with that response. These corrected RTs were expected to decrease with time for congruent trials, while RTs on catch trials would increase relative to congruent trials as an indication of learning the trained contingencies. AST-T RT data were lost from one participant due to equipment failure. Accuracy was near the ceiling for all participants ($M = 98.9$ %, $SD = 1.4$) and therefore not further considered in the analyses.

Assessment of implicit past/nowness associations

The Implicit Association Test (IAT; Greenwald et al., 1998) served to assess implicit associations between the two sets of film reminder pictures and the semantic concepts of the past and the present. Using the task layout described in Greenwald, Nosek, and Banaji (2003), participants initially underwent a training phase in which they learned to categorize pictures of the two trauma films as quickly and as accurately as possible during 20 trials (with

10 pictures from each film). For this purpose, they were instructed to use left and right response buttons on the keyboard corresponding to the target categories “civil war” and “car crash” that were displayed on the top left and right of the computer screen. Next, a second training phase of 20 trials followed, in which they were trained to categorize single word stimuli using the same response buttons, 10 corresponding to the attribute dimension “now“ and 10 to the dimension “past”. In the following two test blocks, participants were alternatingly presented with trials of one and then the other type of stimulus. Now, they were required to use the same two response buttons to categorize either the target category or the attribute dimension, both labels being displayed on the top left and right of the screen. Thereby, compatibility between target and attribute was expected to affect response speed. For example, participants trained to associate civil war stimuli with “past” and car crash stimuli with “now” in the AST-T were expected to display faster responses when the same response key had to be used for civil war images and “past” words, as opposed to a training–incompatible pairing of car crash images and “past” words. In line with Greenwald et al. (2003), the two consecutive test blocks were asymmetric in length and comprised 20 and 40 trials, respectively. Next, left and right response buttons for the target categories (but not the attributes) were swapped and participants underwent another training phase of 20 trials, in which they categorized reminder pictures. This was followed by two additional test blocks of 20 and 40 trials. Thereby, each participant underwent two test blocks with training-compatible response pairings and two test blocks with training-incompatible pairings (see Table 1), the order being counterbalanced across participants. Twenty images serving as picture stimuli were taken from the same sets previously used in the AST-T, but presented without the coloured frames. The word stimuli consisted of 20 synonyms for each attribute dimension (e.g., now: *current*, *here*; past: *over*, *then*).

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Table 1. Sequence of practice and test blocks in the IAT.

Block	Trials	Function	Image / word category assigned to left response key	Image / word category assigned to left response key
1	20	Practice	Civil war	Car crash
2	20	Practice	Now	Past
3	20	Test	Civil war + Now	Car crash + Past
4	40	Test	Civil war + Now	Car crash + Past
5	20	Practice	Car crash	Civil war
6	20	Test	Car crash + Now	Civil war + Past
7	40	Test	Car crash + Now	Civil war + Past

Note. For participants who had previously learned the contingencies "civil war film – now" and "car crash – past" in the AST-T, blocks 3 and 4 probe pairings that are compatible with the training, whereas blocks 6 and 7 probe incompatible pairings. The positions of blocks 1, 3, and 4 were exchanged with blocks 5, 6, and 7 for half of the participants in a counterbalanced manner.

Accuracy and RT was recorded on each trial. Analogue to the revised scoring algorithm developed by Greenwald et al. (2003), trials with inaccurate or extremely slow responses (i.e., >10 s) RTs were replaced by the mean of correct responses the respective block plus 600 ms. We then calculated mean RT across blocks for each target × attribute combination. Furthermore, we calculated the measure *D* following Greenwald et al. (2003) separately for each target film by subtracting the mean RT of trials measuring compatibility with the attribute "past" from trials with the attribute "now", divided by the pooled standard deviation of these trials, whereby the two test blocks per combination were given the same weight (also referred to as D_{600}-measure; for review, see Glashouwer, Smulders, de Jong, Roefs, & Wiers, 2013). Accordingly, higher scores indicate a relatively stronger association between the respective target film and the attribute “past”, as compared with the attribute “present”. Finally, for the purpose of correlation analyses, we calculated an overall relative *D* score to summarize the relative strength of past/present preference between the two target films. In particular, we subtracted RT on compatible trials (i.e., same button for $Target_{Now}$ pictures and “now” words, and for $Target_{Past}$ pictures and “past” words) from RT on incompatible trials (i.e., with opposite pairings, dividing the difference by the pooled standard deviation and in line with the Greenwald et al. (2003) algorithm. Higher overall relative *D* scores indicate that the films trained to be associated with the past and the present, respectively, were indeed associated more strongly with the past or the present, in contrast to the opposite pairings. In the present sample, mean accuracy excelled 91.6 % in each individual test block (range: 70.0–100.0), accuracy across all test blocks being at 93.8 % (*SD* = 3.3; range: 83.3–100.0).

Free recall

Participants were asked to provide a free recall of one film and then of the other (order counterbalanced across participants). They were instructed to write down any act or event, as well as the people who were involved and their appearance, into a text document using a desktop computer. It was emphasized that each report should be as complete and accurate as possible, without guessing any details. The reports were spell-checked and analysed using the Linguistic Inquiry and Word Count (LIWC) program (Tausczik & Pennebaker, 2010), yielding the word counts as well as the relative frequency of present tense and past tense verbs.

Assessment of intrusions and analogue PTSD symptoms

Involuntary memories of the films were assessed with a structured one-week pen and paper intrusion diary (Holmes et al., 2009; Meyer et al., 2013). Participants were instructed to record intrusive memories as soon as they occur, or the absence of intrusive memories at least twice per day. For each memory, they were then asked to provide details about their content and trigger, allowing us to determine whether it was valid and pertained to one (or both) of the trauma films. Participants furthermore indicated whether the memory was based on images, thoughts, or both. Finally each memory was rated in terms of distress and vividness on 11-point scales (0 = *not at all*; 10 = *extremely*). The number of intrusive memories were summed separately for each trauma film and logarithm transformed (ln[1 + # intrusions]) for the analyses.

In addition to the diary, intrusion symptoms were assessed at one-week follow-up by means of two versions of the revised Impact of Event Scale-revised (IES-r; Maercker & Schützwohl, 1998). The two versions had adapted instructions to measure analogue PTSD symptoms specifically related to viewing each of the two trauma films, respectively referred to with the labels “civil war” and “car crash” that participants were familiar with from the IAT. The IES-r requires respondents to indicate the frequency of stress-related symptoms on four-point scales. The Intrusion Symptoms subscales (αs > .83) were of particular interest, while the total scores (αs > .85) served as additional measures of overall analogue PTSD symptoms.

Affective responses

Current affect levels were monitored repeatedly using a German translation of the Positive and Negative Affect Schedule – short form (I-PANAS-SF; Thompson, 2007), which consists of two 5-item scales with adjectives representing positive affect (PA; e.g., active) and negative affect (NA; e.g., afraid). Participants were asked to rate the intensity of each feeling on 5-point scales (1 = *not at all*, 5 = *extremely*). Due to the nature of the films, only NA scores (αs > .53) were included in the analyses.

Procedure

Participants were invited to two individual laboratory sessions separated by a one-week interval. In the first session, they were equipped with headphones and were shown the two different trauma films (order counterbalanced across participants). They were instructed to watch the films attentively without looking away, as if they were a bystander of the shown scenes. An experimenter remained in the room and in exceptional cases, reminded participants to watch the films attentively. The experimenter was seated outside of the participant's view and was instructed to refrain from discussing the content or emotionality of the films with the participants, in order to minimize memory modulation through social feedback (e.g., Takarangi & Strange, 2010). Current affect levels were monitored with the I-PANAS-SF before and after each film. Additional resting periods lasting 1 min were inserted following each film. Afterwards, they underwent the AST-T, followed by the IAT. Finally, they were given the one-week diary and received extensive verbal instructions regarding its use. Upon return to the lab one week later, the diary was turned in and checked for legibility by an experimenter. Participants then filled out the two IES-r versions, followed by the free recall tasks for each film (counterbalanced order across participants). Finally, they were thanked, compensated and dismissed.

Statistical analyses

In our tests of the experimental training effects, the critical independent variable is Target (1: film trained with past, 2: film trained with now; within-subjects). Furthermore, we included the between-subjects factor Film-Target Combination (1: car crash–now and civil war–past; 2: car crash–past and civil war–now) in in all main analyses. This allowed us to effectively disentangle main effects of the AST-T from main effects due to differences between the two films, which are modelled by the interaction of Target × Film-Target Combination. In addition, we repeated the analyses entering the order in which participants viewed the two films as a second between-subjects factor. Since film order only changed the time course of acute negative affect (see below), we only report it for those analyses. Thus, for all other analyses reported below, Film-Target Combination is the only between-subjects factor. Among the key dependent variables were IAT RTs, as well as present versus past tense use in the free recall (i.e., to assess transfer of the AST-T effects). Finally, frequency and intensity of intrusive memories recorded in the diary as well as retrospective intrusion symptoms constitute the main outcome variables.

Next to addressing experimental effects, we tested for linear associations between implicit time associations and intrusion symptoms. In particular, the IAT's overall relative *D* score reflecting the relative strength of the trained associations between the two films served as the independent variable, and the percentage difference in intrusion symptoms between the two target films served as the outcome variable. In other words, we tested whether participants who associated the $\text{Target}_{\text{Now}}$ film preferentially with the "now" category and the $\text{Target}_{\text{Past}}$ film with the "past" category developed relatively more intrusive memories for the $\text{Target}_{\text{Now}}$ film. Percentage difference was calculated as: $[(\text{Target}_{\text{Now}} - \text{Target}_{\text{Past}}) * 100] / [(\text{Target}_{\text{Now}} + \text{Target}_{\text{Past}}) / 2]$ after adding a constant of 1 to each target score, in order to include cases in which one of the two target scores was zero. Within-subject effects and group differences were addressed using mixed-design analyses of variance (ANOVAs) and *t*-tests. When sphericity assumptions for ANOVA were violated, Greenhouse-Geisser corrected *p*-values are reported along with the respective epsilon and uncorrected degrees of freedom. Linear associations were assessed using linear regression analyses. Alpha was set at .05 (two-tailed) for all analyses. Although the main focus of the ANOVAs was on the within-subjects factor Target, we conservatively set the sample size at 96 (using G*Power V.3) in order to retain a power (1 – β error probability) of > .80 for the detection of small-to-medium size within-between interactions ($f = 0.175$) involving Film-Target Combination and the order of film presentation (i.e., 2×2 groups). All statistical tests were performed using IBM SPSS (Version 25).

Results

Acute negative affect

A 3 (Time: pre-film 1, post-film 1, post-film 2) × 2 (Film Order: car crash–civil war, civil war–car crash) × 2 (Film-Target Combination: car crash–now and civil war–past, car crash–past and civil war–now) ANOVA for NA scores revealed a Time by Film Order interaction, F (2,184) = 56.2, p < .001, η^2_p = .38. That is, participants who saw the civil war fragments first initially had similar pre-film NA scores (M = 6.0, SD = 1.4), t (94) = 0.6, p = .547, d = 0.12, but higher scores at post-film 1 (M = 12.6, SD = 3.9), t = 5.9, p < .001, d = 1.22, and lower scores at post-film 2 (M = 10.1, SD = 3.2), t = -4.2, p < .001, d = -0.87, as compared with participants who viewed the films in opposite order (pre-film: M = 5.8, SD = 1.0; post-film 1: M = 8.7, SD = 2.4; post-film 2: M = 13.0, SD = 3.5). Thus, the civil war fragments generally led to a relatively stronger NA increase than the car crash fragments. Meanwhile, the ANOVA showed no unintended 3-way interaction of Time × Film Order × Film-Target Combination, p = .635.

Training effects on the AST-T

As in our control experiment (see Methods), we again found generally faster RTs on correct trials with “now” verbal responses (M = 506.1 ms, SD = 78.6) than for “past” responses (M = 584.6 ms, SD = 87.9), t (94) = 23.1, p < .001, d = 2.07. For the following analyses, we therefore relied on mean-centred RTs per verbal response. A 3 (Epoch) × 2 (Trial Type: congruent, catch) × 2 (Target: film trained with past, film trained with now) × 2 (Film-Target Combination: car crash–now and civil war–past, car crash–past and civil war–now) ANOVA on mean-centred RTs revealed a main effect for Trial Type, F (1,93) = 40.4, p < .001, η^2_p = .30, next to a Trial Type × Target interaction, F (1,93) = 6.1, p = .016, η^2_p = .06. There also was a main effect of Epoch, F (2,186) = 17.1, p < .001, η^2_p = .16, with RTs decreasing from the first (M = 19.4, SE = 3.1) through last epoch (M = -4.3, SE = 2.7), while there was no Trial Type × Epoch interaction, F (2,186) = 1.1, p = .340, η^2_p = .01. Follow-up ANOVAs exploring the Trial Type × Target interaction showed that RTs on catch trials were consistently slower than on congruent trials, which was more pronounced for the target film trained with “past”, F = 40.8, p < .001, η^2_p = .31, than for the target film trained with “now”, F = 18.2, p < .001, η^2_p = .16 (see Figure 2). There were no significant interaction effects in any of the follow-up ANOVAs, all ps > .09. Taken together, our data clearly indicate that the intended learning effect occurred in both targeted directions (i.e., consistently faster RT on congruent than on catch trials). However, this effect did not appear to increase over the course of the task and may have been stronger for the film trained with “past” responses.

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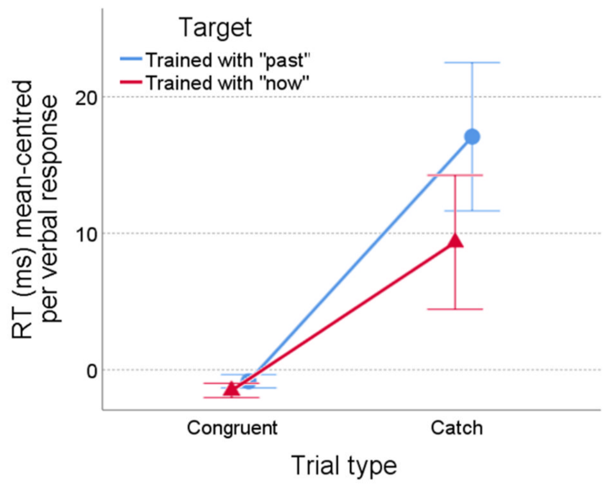

Figure 2. Reaction times (RT) during the AST-T, mean-centred per verbal response, per trial type and target film. Error bars indicate 95% confidence intervals.

Transfer to IAT scores

A 2 (Attribute: present, past) × 2 (Target: film trained with past, film trained with now) × 2 (Film-Target Combination: car crash–now and civil war–past, car crash–past and civil war–now) ANOVA on RT indicated the expected Attribute by Target interaction, F (1,94) = 7.9, p = .006, η^2_p = .08. That is, for pictures of the target film trained with “now”, RTs were shorter for the pairing with the attribute “now” compared to “past”, F (1,94) = 6.7, p = .011,

η^2_p = .07, and vice versa, *F* (1,94) = 6.7, *p* = .011, η^2_p = .07 (see Figure 3, left panel). However, this effect was overlaid by a large three-way interaction, *F* (1,94) = 79.2, *p* < .001, η^2_p = .46. Separate follow-up ANOVAs per Film-Target Combination revealed significant Attribute by Target interactions in both groups, *F*s (1,47) > 19.0, *p*s < .001, η^2_ps > .28, but in opposite directions. That is, that participants who were trained to couple the car crash film with “now” and the civil war film with “past” displayed the Target and Attribute interaction in the expected direction, whereas participants trained to couple the car crash film with “past” and the civil war film with “now” displayed the opposite effects (see Figure 3, two right panels; all simple effect *p*s < .001). As can be seen in Figure 3, these effects resulted from our participants’ clear preference (i.e., shorter RTs) of the pairing between the car crash film and the now attribute as opposed to the past attribute, as well as between the civil war film and the past attribute as opposed by the now attribute (all simple effects *p*s < .001).

These findings are mirrored in the 2 (Target) × 2 (Film-Target Combination) ANOVA on *D* scores, revealing a Target main effect, *F* (1,94) = 8.4, *p* = .005, η^2_p = .08, overlaid by two-way interaction, *F* (1,94) = 90.6, *p* < .001, η^2_p = .49. As can be seen in Table 2, negative and positive *D* scores were revealed for car crash and the civil war film, indicating robust associations with the present and the past attribute, respectively. Importantly, the *D* scores were systematically shifted in the intended direction, overall indicating a successful transfer of the AST-T on implicit associations (see Table 2). In particular, participants who were trained to associate the civil war film with “past” had more positive *D* scores for this film, *t* (94) = 2.5, *p* = .014, *d* = 0.52, and more negative scores for the car crash film that they had learned to associate with “now”, *t* (94) = -2.9, *p* = .005, *d* = -0.59, compared to participants who were trained in the opposite direction.

--- insert Figure 3 about here ---

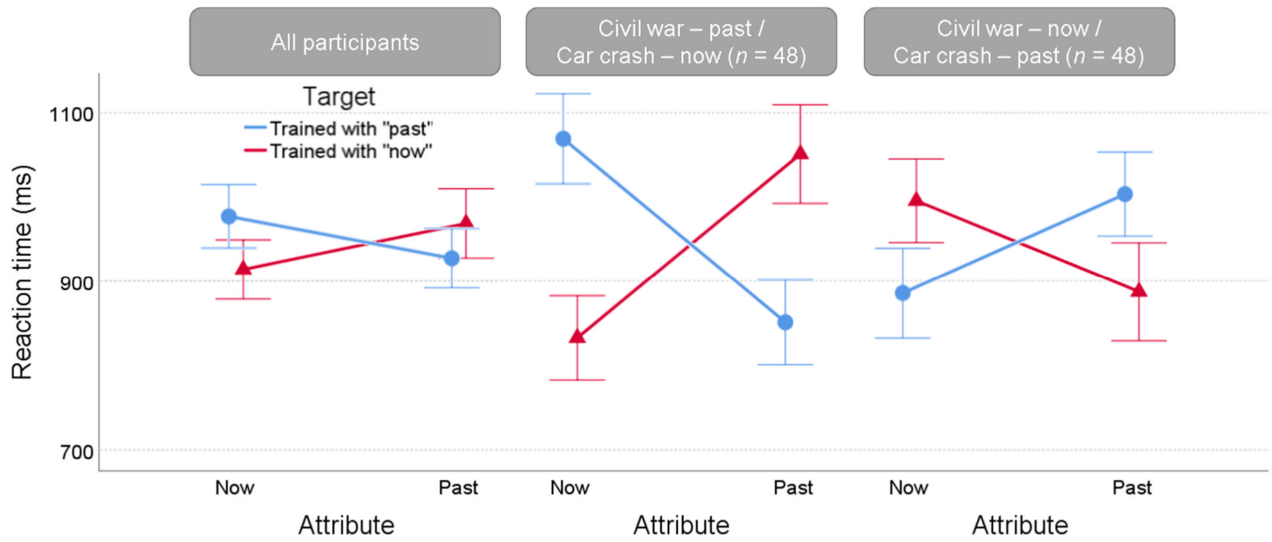

Figure 3. IAT Reaction times per target film and attribute. The left panel (*N* = 96) represents the entire sample, while the two panels to the right represent the subgroups with different target-film combinations. As can be seen, in addition to the training effects due to the AST-T, participants displayed a preference (i.e. shorter RTs) for pairing the car crash film with "now" and the civil war film with "past". Error bars indicate 95% confidence intervals.

--- insert Table 2 about here ---

Table 2. Mean (*SD*) IAT *D* scores reflecting the strength of now/past associations per Target, as well as relatively between Targets.

	D score		
	Trained with "now"	Trained with "past"	Overall relative score
All	-0.16 (0.73)	0.14 (0.71)	0.15 (0.66)
Car crash	-0.64 (0.49) [a]	-0.33 (0.57) [b]	0.61 (0.44) [a]
Civil war	0.33 (0.59) [b]	0.60 (0.50) [a]	-0.31 (0.52) [b]

Note. Positive *D* scores indicate a relatively stronger association of the target with the attribute "past" as compared with "present". Positive overall relative *D* scores indicate that the pairings intended to be trained in the AST-T are stronger than the opposite pairings.

[a-b] cells of the same subsample ($n = 48$).

Transfer to verb tenses at one-week free recall

Before addressing the effects of the AST-T on verb tenses, we first explored whether the free recall records for the two target films differed in terms of total word count or the percentage overlapping with intrusive memories recorded in the diary. The 2 (Target: film trained with past, film trained with now) × 2 (Film-Target Combination: car crash–now and civil war–past, car crash–past and civil war–now) ANOVAs did not indicate any effects of Target, all *p*s > .25. There was only a two-way interaction for word count, $F\ (1,94) = 135.4$, $p < .001$, $\eta^2_p = .59$. Note that a Target × Film-Target Combination interaction essentially indicates a main effect of the Film that is being described. In particular, participants provided longer recall records about the car crash ($M = 278.3$ words, $SD = 135.6$) than about the civil war ($M = 162.8$ words, $SD = 87.4$). Importantly, total word counts in each film did not correlate with the relative frequency of present and past tense use, all *p*s > .38. Meanwhile, the percentages of text overlapping with intrusive memories (overall $M = 13.0\%$, $SE = 1.2$) were similarly unaffected by Target, in the absence of a two-way interaction indicating differences due to the films concerning the, all *p*s > .23.

For the relative frequency of present tense and past tense words, the respective 2 × 2 ANOVAs did not indicate main effects for Target, all *p*s > .21. Again, however, the interactions with Film-Target Combination were significant *p*s < .001, η^2_ps > .28. These effects were due to more present tense words in reports about the car crash ($M = 6.2\%$, $SD = 3.0$) than about the civil war ($M = 3.2\%$, $SD = 2.5$), paralleled by fewer past tense words in the former ($M = 4.4\%$, $SD = 4.4$) than in the latter ($M = 6.3\%$, $SD = 4.0$). For exploration, we repeated these analyses focusing only on text passages of the free recall that overlapped with the diary intrusions in a subset of participants for whom we identified such passages for both films (n = 42). This revealed a practically unchanged pattern (Target ps > .35, interaction ps < .002).

Transfer to intrusive memories

Table 3 summarizes the average number of intrusion-related symptoms, as assessed with the diary and the IES-r. The 2 (Target: film trained with past, film trained with now) × 2 (Film-Target Combination: car crash–now and civil war–past, car crash–past and civil war–now) ANOVAs did not reveal any Target main or interaction effects for intrusions, irrespective of their modality, all Fs (1,94) < 1, ps > .41. Similarly, there were no effects for intrusion vividness or the mean distress caused by the intrusions, Fs < 1, ps > .36. Finally, also the total PTSD scores and the intrusion subscale of the IES-r did not differ as a function of Target or Film, Fs < 1, ps > .32.

--- insert Table 3 about here ---

Table 3. Mean (*SD*) analogue PTSD symptoms, separately for Targets and Films.

Measure		Intrusion content				
		Any	Trained with "now"		Trained with "past"	
			Car crash	Civil war	Car crash	Civil war
Intrusions	Any	4.4 (3.4)	2.0 (2.3)	2.5 (3.4)	2.3 (2.3)	2.3 (2.1)
	Visual	3.3 (2.6)	1.6 (1.9)	1.7 (1.7)	1.6 (1.8)	1.9 (1.9)
	Thought	2.6 (2.9)	1.2 (1.5)	1.7 (3.2)	1.5 (2.0)	1.2 (1.4)
Distress (0-10)		3.2 (2.0)	2.6 (2.1)	2.9 (2.3)	2.7 (2.5)	2.7 (2.1)
Vividness (0-10)		5.1 (2.2)	4.0 (3.1)	4.3 (3.1)	4.7 (3.2)	4.3 (2.7)
IES-r	Total	-	12.6 (12.0)	15.3 (11.8)	17.3 (15.1)	12.3 (9.9)
	Intrusions	-	6.5 (6.7)	7.3 (5.9)	8.6 (7.7)	6.3 (5.2)

Note. IES-r = Impact of Event Scale – revised.

Intrusive memories: Linear associations

Since the overall relative *D* scores on the IAT were strongly dependent on the Film-Target Combination (see Table 2), we evaluated linear associations between relative *D* scores and percentage difference in intrusive memories pertaining to the two trauma films using hierarchical regression analyses. To control for a potential influence of Film-Target Combination, this factor was entered in the first step (i.e., dummy variable; 0 = car crash–now and civil war–past; 1 = car crash–past and civil war–now), which did not yield any significant models, all Fs (1,94) < 0.7, ps > .41, r^2 < .01, with all Film-Target Combination βs < .084. However, adding relative *D* scores in the second step revealed consistent positive associations with all PTSD analogue symptoms. These models are summarized in Table 4. As can be seen, Film-Target Combination received positive and significant regression weights in all these models as well, despite being statistically unrelated to the criterion. That is, due to its association with the main predictor, Film-Target Combination acted as a suppressor variable (Horst, 1941), and its inclusion increased the variance explained by overall relative *D* score (for details on all regression models and zero-order correlations, see Table S-1, supplemental materials). Finally, to explore potential interactions between relative *D* scores and Film-Target Combination, the interaction term (i.e., z-transformed *D* scores multiplied by Film-Target Combination dummy variable) was entered in a third step. The interaction term did not receive a significant weight or explained additional variance in any of the models, all Fs_{change} (1,92) < 1, ps > .32, r^2_{change} < .01, with interaction term βs > -.175, ps > .32.

Figure 4 illustrates the pattern of regression results. It exemplifies that the factor Film-Target Combination had a main effect on overall relative *D* scores (see also Table 2) but not on intrusive memories, and we found no moderation effects on the link between *D* scores and intrusive memories. Table S-2 (supplemental materials) shows that the relationship between IAT scores and intrusive memories can also be understood in terms of differences between the films (car crash, civil war) rather than target. That is, participants who associated the car crash film more strongly with "past" and the civil war film with "now", in contrast to the opposite pairings, experienced relatively fewer intrusive memories for the car crash film than for the civil war film (for details, see Table S-2).

--- insert Table 4 about here ---

--- insert Figure 4 about here ---

Table 4. Summary of the second hierarchical regression model with relative D scores controlled for the factor Film-Target Combination.

Percentage difference ($Target_{Now}$ – $Target_{Past}$)		Beta coefficients		Model statistics	
		Film-Target Combination	Relative *D* score	*F (2,93)*	r^2
Intrusions	Any	.318*	.370**	3.72*	.074
	Visual	.311*	.325*	3.05	.054
	Thought	.280*	.313*	2.67	.050
Distress		.431**	.498***	7.24**	.135
Vividness		.305*	.403**	4.28*	.084
IES-r	Total	.400**	.481***	6.54**	.104
	Intrusions	.408**	.480***	6.60**	.124

Note. Higher relative *D* scores indicate that the relative now/past associations align more strongly with those trained in the AST-T, while higher percentage difference scores reflect more intrusion symptoms for the film paired with "now" during the AST-T than the film paired with "past". IES-r = Impact of Event Scale – revised.

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

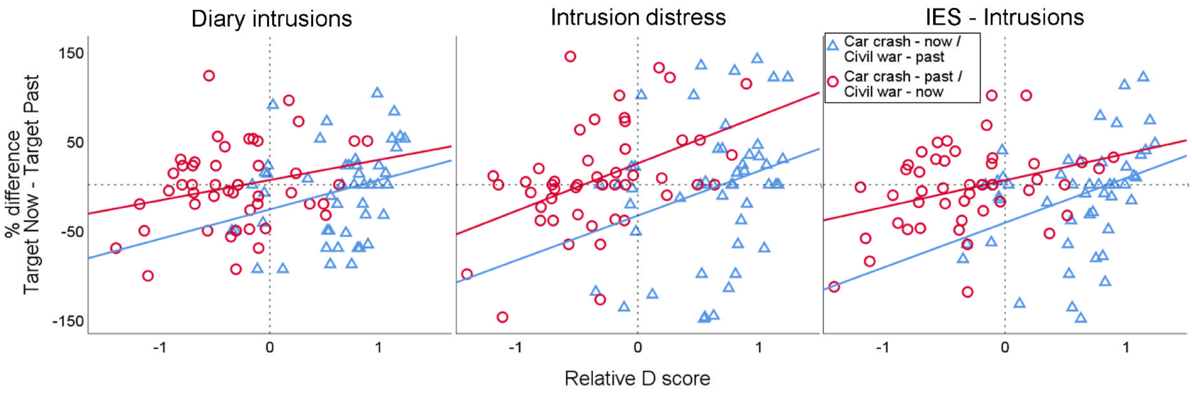

Figure 4. Scatterplots illustrating the correlations between relative *D* scores and differences in analogue PTSD symptoms between the target films, taking the Film-Target Combination into account. Higher relative *D* scores indicate that the relative now/past associations align more strongly with those trained in the AST-T, while higher percentage difference scores reflect more intrusion symptoms for the film paired with “now” during the AST-T than the film paired with “past”. IES-r = Impact of Event Scale – revised.

Discussion

The present study addressed the role of automatic spatio-temporal associations with trauma-related memory cues in the development of intrusive memories. For this purpose, we used an AST-T (Ikani et al., 2019) to train contingencies between two trauma films and verbal “now” or “past” responses, and afterwards measured implicit time associations of reminder pictures from each film using an IAT. As intended, the reminder pictures of the target film trained with “now” responses indeed became more strongly associated with the response attribute “now” as opposed to “past” on the IAT, with the opposite pattern for pictures of the film trained with “past” responses. These training effects were independent of differential associations for the two trauma films, with the film depicting a car crash being more strongly associated with the “present” and the film depicting footage of the Rwandan civil being preferentially associated with the “past”. Despite the transfer effects on the IAT, the AST-T did not have an impact on past or present tense use in free recall records after one week, and there were also no effects on the development of analogue PTSD symptoms. Still, our data clearly indicate that participants who associated pictures from the “now” and “past” target films more strongly with the attributes “now” and “past” in the IAT, respectively, also developed more intrusion symptoms for the “now” than the “past” target film, both in terms of diary intrusive memories and retrospective IES-r scores.

Our data suggest that the AST-T may have resulted in a successful manipulation of implicit associations between trauma reminders and spatio-temporal concepts. If similar transfer effects can be replicated and extended, they may add a promising new intervention approach to the emerging field of cognitive bias modification in PTSD (Woud et al., 2017). However, the AST-T had no direct transfer effects on the development of intrusive memories. At first sight, this finding appears to be at odds with the key assumption that intrusive memories, as well as the characteristic feeling of nowness, result from a lack of contextual embedding of traumatic memories as events of the past rather than the present (Brewin et al., 2010; Ehlers & Clark, 2000; Foa et al., 1989). However, it may be premature to interpret the absence of an experimental training effect on intrusive memories, since an alternative interpretation is that our training had rather weak and short-lasting effects. In line with this view, we also failed to observe a transfer of the association training on the frequency of present and past tense use in free recall reports for the two trauma films one week after film viewing. Together, these results might indicate that the training effects were too short-lasting to influence the development of intrusive memories in the course of a week. Indeed, this interpretation mirrors a general challenge for cognitive bias modification to extend training effects over time (Koster et al., 2009; Woud et al., 2017).

Strikingly, the regression analyses clearly revealed that participants who associated one of the trauma films more strongly with the present and the other film the past, also developed relatively more PTSD analogue symptoms for the former compared to the latter film. This result was consistent for intrusion frequency, distress, and vividness, as well as retrospective intrusion symptoms on the IES-r. Taken together, these findings lend persuasive support for a link between intrusion symptoms and the degree to which traumatic memories are embedded in their spatio-temporal context, as postulated in information processing accounts of this disorder (Brewin et al., 2010; Ehlers & Clark, 2000; Foa et al., 1989). Notably, the present study was not able to clarify whether automatic time associations indeed play a causal role in intrusive memories.

Studies following up on these results might require a more potent manipulation of implicit time associations than our AST-T. Although we did observe a clear learning effect during the AST-T, such that participants were slower to respond on catch trials than on training trials, this learning effect did not increase during the task. A possible interpretation is that our training was relatively easy and did not require a level of processing that would require an actual change in automatic associations. For instance, this could suggest that the effects on the IAT have been driven by shifts in the salience of certain combinations rather than of the underlying associations (De Houwer, Geldof, & De Bruycker, 2005). Accordingly, a more pervasive change in memory might be required to change the development of traumatic intrusions. Thus, more generally speaking, the question whether a computerized training can reduce traumatic memories (e.g., by increasing the automatic accessibility of contextual information) remains to be answered empirically. Training effects might be improved by extending the training over more sessions or by increasing the training difficulty. For instance, stronger learning effects over the course of the task might be achieved by making the response-relevant feature harder to detect. In addition, future studies may want to address whether the acquisition of implicit associations with temporal information is moderated by acute stress or mood reactivity (e.g., Meyer, Quaedflieg, Bisby, & Smeets, 2019). At the same time, future research might benefit from assessing the training effects, which we assumed to operate on an implicit and automatic level, to more explicit subjective appraisals of the 'nowness' quality of memory (e.g., sense of current threat, etc.). Finally, the present experimental approach needs to be complemented by investigating the extent to which the AST-T or similar trainings might reduce the frequency and vividness of intrusive memories among traumatized individuals with PTSD. This might be investigated as a stand-alone intervention or as an add-on to psychological treatment, whereby idiosyncratic reminder cues might serve as training targets.

A few limitations merit to be mentioned. First and foremost, we used an analogue design with healthy participants, and our results may not translate directly to traumatized samples. For instance, our participants may have been able to encode the traumatic films with sufficient spatio-temporal context, resulting in intrusive memories with low levels of 'nowness'. In a similar vein, we relied on a within-subjects cross-over design, implying that all effects of interest are bound to the difference in intrusive memories between the two different trauma films that we used. This approach has the advantage of controlling for various individual differences (e.g., the general tendency to develop intrusive memories for any emotional experience). Moreover, our data show that both films were similarly potent in inducing intrusive memories, in line with prior studies (e.g., Meyer et al., 2017; Meyer et al., 2013; see Methods) and despite their differences in acute affective responses (cf. Meyer et al., 2014). Still, a potential limitation is that the level of symptomatology for each trauma film was relatively low (see Table 3), which might have led to floor effects. Relatedly, some effects may have been reduced due to characteristics of one of the used films (including floor or ceiling effects) that went undetected or introduced noise and reduced the statistical power of our analyses. Yet, we found no indication that AST-T effects or correlations with intrusive memories differed from one film to the other. Finally, the voice-based measurement of RT during the AST-T has the inherent limitation that systematic RT differences due to the rise times of the verbal responses need to be corrected for, while differences in pronunciation and occasional background noises (e.g., coughing) may introduce unexplained variance, overshadowing some of the experimental effects.

In attempts to replicate and extend our findings, researchers should weigh potential advantages of the current design against alternatives. Although our design allowed us to disentangle AST-T effects from main effects associated with the different films, it can be argued that a replication would benefit from using trauma films that do not differ in their likelihood of being associated with the present or the past (e.g., Stuart, Holmes, & Brewin, 2006). These might include films of other trauma types than the ones used in the present study (for reviews, see Arnaudova & Hagenaars, 2017; Weidmann, Conradi, Grögera, Fehma, & Fydrich, 2009). In particular, it may have been generally easier to associate the fragments about the Rwandan civil war with the past and the car crash fragments with the present. Our data clearly support this view, as there were large differences between the films for present versus past tense use in the free recall, paralleled by different implicit association scores in the IAT (see Table 2). However, a potential drawback of using more similar films is that memories may not be encoded independently from one another (e.g., formation of one gist-like memory trace for both films; Theunissen et al., 2017). Therefore, this should be weighed against a between-subject study that manipulates memory for a single trauma film, which might be a promising alternative design.

To conclude, our study provides promising evidence that an automatic association between trauma reminder stimuli and the spatio-temporal past – as opposed to the present – may be associated with fewer intrusive memories, as well as lower associated distress, vividness, and intrusion-related symptoms. While these results await replication and extension, this study provides tentative support to a key theoretical assumption in information processing models of PTSD. However, the causal role of these associations further remains to be investigated experimentally. Notably, following up on this line of research has high clinical potential, since automatic associations with spatio-temporal information may become a novel target in diagnostic and treatment applications for trauma victims. This may eventually contribute to enhanced early intervention strategies, which are currently still very limited (Kearns, Ressler, Zatzick, & Rothbaum, 2012).

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Table S-1. Hierarchical regression models with Film-Target Combination, relative *D* scores, and interaction of Film-Target Combination and *D* scores, on the difference in intrusion symptoms between the two target films.

Percentage difference ($Target_{Now}$ – $Target_{Past}$)		Model	Beta coefficients			Model statistics			Zero-order correlation
			Film-Target Combination	Relative *D* score	Interaction term	*df*	*F*	r^2	Relative *D* score
Intrusions	Any	1	.061			1,94	0.35	<.01	
		2	.318*	.370**		2,93	3.72*	.074	.148
		3	.326*	.452*	-.092	3,92	2.54	.077	
	Visual	1	.084			1,94	0.67	<.01	
		2	.311*	.325*		2,93	3.05	.062	.109
		3	.317*	.387	-.069	3,92	2.06	.063	
	Thought	1	.063			1,94	0.37	<.01	
		2	.280*	.313*		2,93	1.77	.054	.118
		3	.279	.298	.016	3,92	2.67	.054	
Distress		1	.084			1,94	0.67	<.01	
		2	.431**	.498***		2,93	7.24**	.135	.198
		3	.429**	.481*	.019	3,92	4.78**	.135	
Vividness		1	.025			1,94	0.06	<.01	
		2	.305*	.403**		2,93	4.28*	.084	.190
		3	.308*	.432*	-.032	3,92	2.83*	.085	
IES-r	Total	1	.066			1,94	0.41	<.01	
		2	.400**	.481***		2,93	6.54**	.123	.202*
		3	.416**	.638**	-.175	3,92	4.68**	.132	
	Intrusions	1	.073			1,94	0.51	<.01	
		2	.408**	.480***		2,93	6.60**	.124	.196
		3	.423**	.628**	-.164	3,92	4.68**	.132	

Note. Higher relative *D* scores indicate that the relative now/past associations align more strongly with those trained in the AST-T, while higher percentage difference scores reflect more intrusion symptoms for the film paired with "now" during the AST-T than the film paired with "past". IES-r = Impact of Event Scale – revised. In each model 2, Variance inflation Factor (VIF) for *D* scores = 1.40; In model 3, interaction term VIF = 3.37.

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

Table S-2. Hierarchical regression models with Film-Target Combination, *D* scores measuring relative associations between the car crash and the civil war films, and interaction of Film-Target Combination and *D* scores, on the difference in intrusion symptoms between the car crash and the civil war films.

Percentage difference (Film $_{Car\ crash}$ – Film $_{Civil\ war}$)		Model	Beta coefficients			Model statistics			Zero-order correlation
			Film-Target Combination	Relative *D* score (car crash–past & civil war–now)	Interaction term	*df*	*F*	r^2	Relative *D* score (car crash–past & civil war–now)
Intrusions	Any	1	.098			1,94	0.91	<.01	
		2	.179	-.277**		2,93	4.02*	.080	-.224*
		3	.182	-.338*	.079	3,92	2.74*	.082	
	Visual	1	.025			1,94	0.06	<.01	
		2	.097	-.245*		2,93	2.73	.055	-.216*
		3	.099	-.292	.060	3,92	1.85	.057	
	Thought	1	.040			1,94	0.15	<.01	
		2	.109	-.235*		2,93	2.56	.052	-.203*
		3	.108	-.224	-.014	3,92	1.69	.052	
Distress		1	-.022			1,94	0.04	<.01	
		2	.088	-.375***		2,93	6.88**	.129	-.349***
		3	.088	-.362*	-.016	3,92	4.55**	.129	
Vividness		1	.104			1,94	1.03	.011	
		2	.192	-.301**		2,93	4.81*	.094	-.245*
		3	.193	-.322*	.027	3,92	3.18*	.094	
IES-r	Total	1	.140			1,94	1.88	.020	
		2	.250*	-.358***		2,93	7.37**	.137	-.286**
		3	.250*	-.475**	.150	3,92	5.23**	.146	
	Intrusions	1	.115			1,94	1.26	.013	
		2	.217*	-.349***		2,93	6.62**	.125	-.285**
		3	.223*	-.479**	.166	3,92	4.81**	.136	

Note. Higher relative *D* scores indicate a stronger relative association of the car crash film with the past and the civil war film with the present, as opposed to the opposite pairings. Higher percentage difference scores reflect more intrusion symptoms for the car crash film than the civil war film. IES-r = Impact of Event Scale – revised. In each model 2, Variance inflation Factor (VIF) for *D* scores = 1.09; In model 3, interaction term VIF = 2.50.

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