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Effects of imagery rescripting on consolidated memories of an aversive film

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ABSTRACT

Background and objectives: Imagery rescripting (ImRs) is a promising intervention targeting emotional memory. Previous analogue studies have mainly investigated effects of ImRs during memory encoding and consolidation; experimental research on the effects and mechanisms of change in ImRs targeting consolidated memories is largely missing. The present study aimed to investigate effects of ImRs on consolidated memories using a multiple-day trauma film paradigm.

Methods: Eighty-eight participants were randomly assigned to either ImRs, imagery rehearsal (IRE), or no intervention control (NIC). In Session 1, participants watched an aversive film. In Session 2 (24 h after Session 1), the analogue trauma memory was reactivated and the intervention took place. Participants reported intrusive memories of the aversive film for one week and then returned to the laboratory for a follow-up (Session 3).

Results: Compared to IRE, ImRs was experienced as less distressing and elicited less negative emotions. In addition, ImRs accelerated the decline of intrusive memories when compared to NIC. However, ImRs, IRE, and NIC did not differ with respect to the total number of intrusive memories during the week following the intervention.

Limitations: There was a floor effect of intrusive memories, which may have obscured a potential superiority of the active interventions over NIC.

Conclusions: Adding to the current literature on ImRs as an intervention for emotional memories, the current study underscores that a multiple-day trauma film paradigm can be used to investigate the short-term efficacy and working mechanisms of ImRs, but also points toward useful modifications to the paradigm.

1. Introduction

Intrusive re-experiencing constitutes one of the hallmark symptoms of posttraumatic stress disorder (PTSD; American Psychiatric Association, 2013). However, re-experiencing past distressing events in the form of mental imagery is also present in other disorders (Hackmann & Holmes, 2004; Holmes & Mathews, 2010; Holmes, Iyadurai, Jacob, & Hales, 2015). By accessing sensory information from memory rather than from actual perception (Kosslyn, Ganis, & Thompson, 2001), intrusive mental images can evoke strong emotional responses, as if the distressing events were recurring (Dadds, Bovbjerg, Redd, & Cutmore, 1997). The powerful impact of mental images on emotions and subsequent behavior can, however, also be used to alleviate negative emotions by imagining more positive images and thus facilitate the experience of positive emotions (Holmes & Mathews, 2010). Various treatment approaches have therefore embraced imagery as a primary component of therapy and integrated the manipulation of mental images into psychological treatment packages (Edwards, 2007; Hackmann, Bennett-Levy, & Holmes, 2011).

Imaginal exposure (IE) is an evidence-based intervention for the treatment of PTSD, which requires patients to repeatedly confront the traumatic memories in their imagination (Cusack et al., 2016; Rothbaum & Schwartz, 2002). Although IE is highly effective, problems and challenges related to this treatment are increasingly being discussed. For example, many therapists show negative attitudes toward IE and therefore often do not routinely use it in clinical practice (e.g., Becker, Zayfert, & Anderson, 2004). In addition, mentally reliving the traumatic events is often experienced as distressing by patients, leading to relatively high drop-out rates (Arntz, Tiesema, & Kindt, 2007; Swift & Greenberg, 2014; but also see Imel, Laska, Jakupcak, & Simpson, 2013). Finally, IE appears to be more efficacious for the treatment of fear-based than non-fear emotions often observed in PTSD (e.g., anger or guilt; Arntz et al., 2007; Grunert, Weis, Smucker, & Christianson, 2007).

Imagery rescripting (ImRs) is a promising imagery-based treatment that may overcome some of these limitations. ImRs has been used transdiagnostically to change maladaptive memories into more benign and less distressing mental images (Arntz & Weertman, 1999; Holmes, Arntz, & Smucker, 2007; Smucker, Dancu, Foa, & Niederee, 1995). For example, a patient suffering from PTSD may rescript memories of physical assault into a new script that includes successful defense

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against an assailant or the police saving the victim. ImRs has been shown to effectively reduce symptom severity in different emotional disorders (Morina, Lancee, & Arntz, 2017) and appears to result in lower drop-out rates when compared to IE (Arntz et al., 2007). In experimental studies with healthy participants, ImRs has been shown to reduce short-term negative emotions (Seebauer, Froβ, Dubaschny, Schönberger, & Jacob, 2014) and it appears to be less distressing than exposure-based control conditions (Dibbets & Arntz, 2016; Hagenaars & Arntz, 2012). Additionally, there is preliminary evidence from clinical studies that ImRs is more efficacious in changing non-fear negative emotions (e.g., anger or guilt) than IE in PTSD patients (Arntz et al., 2007; Grunert et al., 2007). Despite emerging evidence on the efficacy of ImRs across different disorders (Arntz, 2012; Morina et al., 2017), the working mechanisms underlying ImRs are still largely unknown.

It is generally agreed that ImRs changes emotional memories, but *how* exactly this happens remains a key question. It has been suggested that memory updating mechanisms during reconsolidation may play a crucial role (Arntz, 2012; Brewin, 2006). In order to investigate memory processes implicated in treatments for PTSD (e.g., ImRs, IE), the trauma film paradigm (TFP) has proven an invaluable experimental model. Within the TFP, participants are presented with aversive film clips depicting traumatic events (e.g., road accidents, physical and/or sexual assault). Such film clips have been shown to elicit high levels of distress and short-lived intrusive memories (James et al., 2016). Ensuring high experimental control over the symptom-eliciting stressor, the TFP is generally regarded as a good laboratory analogue to induce trauma-related intrusive memories and emotions. In addition, the efficacy and working mechanisms of interventions aiming at the reduction of these symptoms can systematically be studied using the TFP.

The TFP has been used in a handful of earlier studies to test the effects of ImRs on intrusive memories. Importantly, however, these studies have exclusively focused on the *preventive* effects of ImRs on intrusive memory encoding and/or consolidation by employing the intervention shortly (i.e., 30 min) after the presentation of the aversive film (e.g., Dibbets & Arntz, 2016; Hagenaars & Arntz, 2012; Seebauer et al., 2014). Findings are inconclusive: There are results suggesting that ImRs reduces the development of intrusive memories when compared to IE and positive imagery (Hagenaars & Arntz, 2012). However, there are also findings indicating that only ImRs including the most aversive part of the memory (i.e., hotspot) leads to significantly less intrusive memories than no intervention control, but not IE (Dibbets & Arntz, 2016). Even though these results are promising with regard to ImRs as a preventive treatment technique, the *therapeutic* effects of ImRs on consolidated memories have not yet been systematically studied. In order to investigate not only therapeutic effects of ImRs, but also its underlying mechanisms (e.g., memory updating processes during reconsolidation), an adapted multiple-day protocol of the TFP is needed (see also James et al., 2015). In this article, we propose a study design where participants are presented with the aversive film on Day 1, and undergo an intervention 24 h later on Day 2, i.e., after memory consolidation has taken place.

The aim of the current study was twofold: First, the study aimed to test specific hypotheses regarding differential effects of ImRs vs. imagery rehearsal (IRE). For this purpose, participants were randomly allocated to one of three conditions 24 h after having watched an aversive film: ImRs, IRE, or no intervention control (NIC). IRE was included as an active control condition to compare the effects of ImRs to an exposure-based imagery condition without a rescripting component. Our key assumption was that whereas ImRs and IRE would lead to similar reductions in film-related intrusive memories and would have similar effects on fear emotions, ImRs would be related to less distress and less negative non-fear emotions compared to IRE in the short-term. Specifically, we expected that ImRs would be experienced as less distressing by participants than IRE (hypothesis 1). In addition, we hypothesized that ImRs and IRE would not differ with respect to short-term negative fear emotions, but that ImRs would elicit less negative non-fear emotions than IRE (hypothesis 2). We also expected ImRs and IRE to lead to less intrusive memories following the intervention compared to NIC (hypothesis 3). Given that both ImRs and IRE have previously been shown to effectively reduce the frequency of intrusive memories, we did not expect differences between the two groups on this dependent variable. Secondly, the study aimed to examine based on the hypotheses above whether the multiple-day TFP is a useful experimental paradigm to investigate the differential effects of ImRs.

In addition, we conducted several exploratory analyses: First, the effects of ImRs, IRE, and NIC on the characteristics of intrusive memories including vividness, distress, and controllability were explored. Second, possible differences between the conditions regarding the participants' analogue posttraumatic symptoms and explicit memory recall one week after the interventions were examined.

2. Methods

2.1. Participants

One hundred seven female participants between 18 and 30 years were recruited using social media and advertisements at university campuses. Due to the nature of the aversive film (see Section 2.2.1), the following exclusion criteria were assessed using the German versions of the Mini-International Neuropsychiatric Interview (M.I.N.I.; Ackenheil, Stotz, & Dietz-Bauer, 1999; Sheehan et al., 1998), the Life Events Checklist (LEC; Ehring, Knaevelsrud, Krüger, & Schäfer, 2014; Gray, Litz, Hsu, & Lombardo, 2004), and a screening interview developed for this study: (1) any current psychological disorder, (2) life-time diagnosis of PTSD, bipolar disorder, psychosis, epilepsy, or a severe cardiovascular disease, (3) current pregnancy, and/or (4) severe sexual harassment, sexual or physical abuse experienced either by the participants themselves or by a close friend/relative. Based on these criteria, 17 participants were excluded. Two participants dropped out after session 1, leaving a total sample of 88 participants with a mean age of 22.81 years ($SD = 3.00$).

Participants were randomly assigned to one of three experimental conditions: (1) imagery rescripting (ImRs; $n = 29$), (2) imagery rehearsal (IRE; $n = 29$), or (3) no intervention control (NIC; $n = 30$). At baseline, the groups did not differ in age, $F(2, 85) = 2.04$, $p = .14$, $\eta_p^2 = 0.05$, and trait anxiety on the Spielberger State Trait Anxiety Inventory (STAI-T; Laux, Glanzmann, Schaffner, & Spielberger, 1981; Spielberger, Gorsuch, & Lushene, 1970), $F(2, 85) = 0.68$, $p = .51$, $\eta_p^2 = 0.02$.

Participants provided written informed consent and received partial course credit or a monetary reimbursement (30€). The study was approved by the local Research Ethics Committee (09 Siegesleitner_b).

2.2. Material

2.2.1. Aversive film

In the first experimental session, a 13 min fragment from *Irreversible* (Noé, 2002) was used to elicit analogue posttraumatic reactions. It is known to induce negative emotional responses, subjective distress, and intrusive memories (Arnaudova & Hagenaars, 2017; Weidmann, Conradi, Gröger, Fehm, & Fydrich, 2009). The aversive film comprised two different events: (1) a man raping a woman (*rape*) and (2) the man beating up the woman afterwards (*beating*). We expected that participants would differ as to which of these events they found most aversive. Therefore, participants were asked to indicate their individual hotspot directly after watching the aversive film.

2.2.2. Memory reactivation task

Participants returned to the lab 24 h after having watched the aversive film for a second session, in which the interventions (see 2.3) were applied. Based on the assumption that memory updating mechanisms during reconsolidation may play a crucial role in ImRs (Arntz, 2012), a memory reactivation task was used in the second session prior to the intervention to reactivate the analogue trauma memory and to allow for reconsolidation processes to initiate. Memory updating via reconsolidation processes can only occur when expectancies are violated during memory retrieval (prediction error; for a review, see Exton-McGuinness, Lee, & Reichelt, 2015). To induce a prediction error, participants were given the same written instruction as prior to the aversive film. However, instead of the aversive film, 11 still images from the beginning of the film (i.e., before the rape) were presented. Each image was presented for 2 s in the same order as they had appeared in the film. Next, participants had a 10 min break with a standardized music filler task (see also James et al., 2015).

2.3. Interventions

In ImRs and IRE, participants were instructed to close their eyes and imagine everything that followed as vividly as possible. Both active interventions started with the explanation and demonstration of an imagery exercise provided by the experimenter. Then, the experimenter read out loud a 2.5 min standardized narrative of the beginning of the aversive film. The purpose of this narrative was to reactivate the emotions related to the aversive film, as this is deemed necessary to later address these emotions in treatment (Arntz, 2012; Dibbets & Arntz, 2016). In light of previous findings suggesting that ImRs may be more effective if the participant's individual hotspot of the memory is included (Dibbets & Arntz, 2016), the emotion reactivation narrative ended with the individual hotspot (*rape* or *beating*, see 2.2.1). Thereafter, subjective distress (SUD, see 2.4.1.1) was assessed verbally, while participants kept their eyes closed. Participants were then instructed to either rehearse (IRE) or rescript (ImRs) the course of events of the aversive film that followed their individual hotspot. In both conditions, they were instructed to keep their eyes closed, and to imagine the scene as vividly and with as much sensory details as possible. Participants were asked to describe the mental images out loud from the first-person perspective and in present tense. In order to increase comparability between ImRs and IRE, both interventions were slowly ended by the experimenter after 8–12 min.

2.3.1. Imagery rescripting (ImRs)

In ImRs, participants were asked to change the aversive film in any way they wished (realistic or unrealistic), as long as it resulted in a more satisfying outcome. Moreover, participants were encouraged to imagine ways to disempower the perpetrator and save the victim either themselves or by having a helper enter the image (e.g., police).

2.3.2. Imagery rehearsal (IRE)

During IRE, participants were instructed to vividly reimagine the entire aversive film. If participants finished in less than 8 min, they were asked to imagine the scene for a second time.

2.3.3. No intervention control (NIC)

Participants in NIC did not receive the standardized emotion reactivation narrative nor an intervention but had a 15 min break during which they read neutral magazines provided by the experimenter.

2.4. Measures

2.4.1. Primary outcome measures

2.4.1.1. Distress. Participants rated their subjective units of distress (SUD) on a scale from 0 (*Not distressed at all*) to 100 (*Extremely distressed*). SUD was measured before and after the aversive film, the memory reactivation task, and the intervention, as well as at one-week follow-up. Additionally, participants verbally indicated their SUD every 3 min during the ImRs and IRE interventions.

2.4.1.2. Mood ratings. Visual analogue scales (VAS) ranging from *Not at all* (0) to *Very much* (100) were used to measure participants' response to the aversive film, the memory reactivation task, and the interventions on two fear (anxiety, horror) and five non-fear emotions (anger, sadness, shame, guilt, disgust).

The German version of the Positive and Negative Affect Schedule (PANAS; Krohne, Egloff, Kohlmann, & Tausch, 1996; Watson, Clark, & Tellegen, 1988) was used to assess changes in positive (PA) and negative (NA) affect in response to the aversive film and the interventions. In the current study, internal consistencies were acceptable to excellent (PA: Cronbach's α = .78–.94, NA: Cronbach's α = .64–.92).

2.4.1.3. Intrusive memories. Participants reported film-related intrusive memories using a smartphone app (movisensXS). The questions asked via the app were identical to those commonly used in paper tabular diaries (e.g, James et al., 2015). Specifically, participants reported (1) the type of each intrusive memory (image, thought, or combination of image and thought), (2) its content, (3) the trigger situation, and (4) accompanying emotions. Moreover, participants indicated (5) distress, (6) vividness, and (7) perceived controllability on a scale from 0 (*Not at all*) to 10 (*Very much*). Intrusive memories were defined as spontaneously occurring involuntary memories of the aversive film. Participants were instructed to report intrusive memories immediately after they occurred. To improve adherence, the app reminded participants every evening to record any intrusive memory missed during the day. All recorded intrusive memories (i.e., triggered by reminders and spontaneous entries) were included in the analyses.

2.4.2. Secondary outcome measures

2.4.2.1. Analogue posttraumatic symptoms. An adapted version of the Impact of Event Scale-Revised (IES-R; James et al., 2015; Maercker & Schützwohl, 1998; Weiss & Marmar, 1997) was used as a measure of analogue posttraumatic symptoms. Using a 5-point Likert scale ranging from 0 (*Not at all*) to 4 (*Extremely*), participants rated 22 items in reference to the aversive film on how much they experienced each symptom during the past seven days. In the current study, the adapted version of the IES-R showed good internal consistencies (intrusions: Cronbach's α = .85, avoidance: Cronbach's α = .72, hyperarousal: Cronbach's α = .79).

2.4.2.2. Explicit memory recall. Explicit memory regarding the content of the aversive film was assessed in session 3 using a questionnaire adapted from Hagenaars and Arntz (2012), where the questions were altered in order to refer to the aversive film used in this study. The memory recall test consisted of 12 questions with open answers format (e.g., "How many people witness the rape?").

2.5. Procedure

The experiment consisted of three sessions across eight days. Session 2 took place 24 h (± 3 h) after session 1, and session 3 took place six days (± 3 h) after session 2. All questionnaires were assessed digitally using the online survey software *Unipark*® (v.EFS10.9). For details on the procedure, see Fig. 1.

2.6. Statistical analyses

Daily as well as the total number of intrusive memories post-intervention (sum score days 2–7) were computed from the diary data. One day was defined as an individual 24 h window. The first time window (baseline, day 1) started immediately after session 1 and ended with session 2. Each diary record was coded by two independent raters who were blind to condition. Inter-rater reliability was excellent (κ = 1.00). Means for the baseline and the post-intervention period were calculated for vividness of, control over, and distress elicited by the intrusive memories.

As manipulation checks for the aversive film and the memory

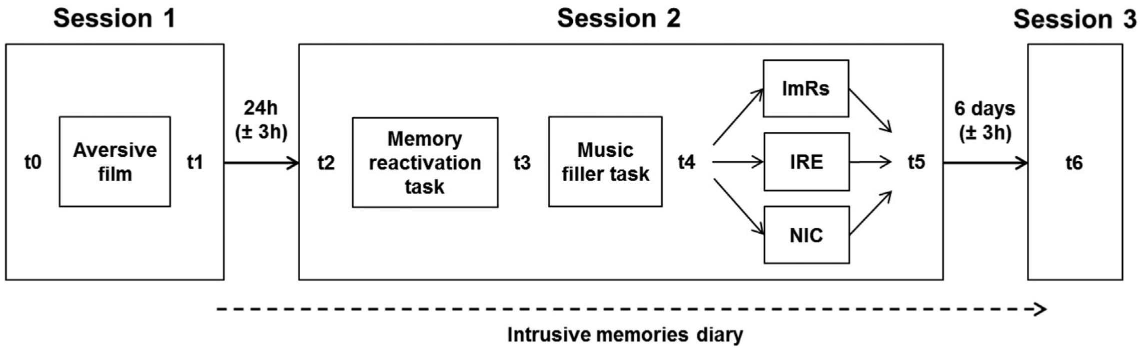

Fig. 1. Experimental procedure.
Session 1: After having provided written informed consent, participants were screened for exclusion criteria. Eligible participants were presented with baseline measures including sociodemographic questions, SUD, VAS, and PANAS (t0). Next, they received instructions for the aversive film, in which they were asked to imagine themselves as bystanders of the scene. After having watched the aversive film, SUD, VAS, and PANAS were repeated (t1) and the app-based intrusive memories diary was explained. Participants started using the diary app immediately after session 1 and continued using it until session 3.
Session 2: At the participants' return to the laboratory, SUD and VAS were assessed (t2). Next, the memory of the aversive film was reactivated by means of the memory reactivation task followed by SUD and VAS assessment (t3), and a 10 min break with a music filler task. Thereafter, SUD, VAS, and PANAS were measured once more (t4). Next, participants were randomly assigned to ImRs, IRE, or NIC. Following the interventions (or NIC), SUD, VAS, and PANAS were reassessed (t5). Finally, participants were explicitly reminded to continuously report intrusive memories until session 3.
Session 3: SUD, VAS, PANAS, IES-R, and explicit memory recall were assessed (t6) and participants were debriefed.

reactivation task, 2 × 3 repeated measures analyses of variance (ANOVAs) with Time (t0 vs. t1 or t2 vs. t3) as within-subject factor and Condition (ImRs, IRE, NIC) as between-subjects factor were calculated for SUD, PANAS, and VAS.

To investigate whether ImRs was experienced as less distressing than IRE, a 4 × 2 repeated measures ANOVA was conducted with Time (assessments during the interventions) as within-subject factor and Condition (ImRs, IRE) as between-subjects factor. In order to test whether ImRs leads to a stronger reduction in negative emotions than IRE, 2 × 3 repeated measures ANOVAs with Time (t4, t5) as within-subject and Condition (ImRs, IRE, NIC) as between-subjects variable were calculated for VAS and PANAS-NA. Effects of ImRs, IRE, and NIC on PANAS-PA were explored by calculating a repeated measures ANOVA (t4, t5). To test whether ImRs and IRE lead to less intrusive memories post-intervention when compared to NIC, univariate ANOVAs were calculated on the total number of intrusive memories at baseline and post-intervention. Group differences on the number of participants who did not experience any intrusive memories at baseline or post-intervention were explored using chi-square tests.

To further examine the course of intrusive memories, we estimated a two-level Poisson regression model with random intercepts and random slopes. In this model, intrusive memories were predicted by Days (Level 1, within-subject), Condition (Level 2, between-subjects), and their cross-level interactions. We assumed a correlation between intercept and slope to model the 'baseline effect', where higher baseline scores might be associated with greater reductions after the interventions. The model was estimated by using SAS v.9, PROC NLMIXED.

Group differences regarding characteristics of intrusive memories, explicit memory recall, and IES-R scores were tested using univariate ANOVAs.

In case of violation of the sphericity assumption in repeated measures ANOVAs, Greenhouse-Geisser degrees of freedom correction was used. Following up on significant interactions, post-hoc *t*-tests regarding changes within each condition and pairwise comparisons on different time points were performed. Criterion for significance was set at $p < .05$ for all analyses, and partial eta squared (η_p^2), Cohen's *d* or Cramer's *V* were used as effect sizes. For post-hoc tests the α-error rate was controlled using Bonferroni correction.

3. Results

3.1. Manipulation check

For the aversive film and the memory reactivation task repeated measures ANOVAs revealed significant main effects of Time (t0 vs. t1 or t2 vs. t3) for SUD and VAS, $Fs > 13.85$, $ps < .001$, $\eta_p^2s > 0.14$, indicating significant increases in negative emotions and distress. Neither the main effects of Condition nor the Time × Condition interactions were significant for SUD ($Fs < 0.76$, $ps > .47$, $\eta_p^2s < 0.02$) or the VAS after using Bonferroni-adjusted alpha levels of .007 per test (α = .05/7), $Fs < 4.39$, $ps > .02$, $\eta_p^2s < 0.09$ (for descriptive statistics, see Table A1 in the Supplementary material).

3.2. Distress during the intervention (hypothesis 1)

A repeated measures ANOVA revealed a significant Time × Condition interaction, indicating group differences in SUD over time during the intervention, $F(2.55, 137.48) = 36.10$, $p < .001$, $\eta_p^2 = 0.40$. As expected, pairwise comparisons at different time points did not reveal a significant difference between the groups after the standardized emotion reactivation narrative ($p = .94$, $d = 0.02$), but at 3 min, 6 min, and the end of the intervention ($ps < .001$, $ds > 0.99$). In line with the hypothesis, participants in ImRs reported significantly lower SUDs than participants in IRE at the three time points, see Fig. 2.

Table 1
Multilevel Poisson regression model for the course of intrusive memories.

	Estimates (*SD*)	95% CI	*t*	*p*
Fixed effects				
Intercept				
Intercept	0.95 (0.20)	[0.55, 1.35]	4.80	< .001
ImRs vs. NIC	0.63 (0.26)	[0.12, 1.15]	2.40	.02
IRE vs. NIC	0.22 (0.27)	[-0.32, 0.75]	0.81	.42
Slope				
Intercept	-0.40 (0.07)	[-0.54, -0.27]	-6.05	< .001
ImRs vs. NIC	-0.19 (0.09)	[-0.37, -0.02]	-2.24	.03
IRE vs. NIC	-0.10 (0.09)	[-0.27, 0.07]	-1.15	.25
Random effects				
Intercept	-0.39 (0.16)	[-0.71, -0.08]	-2.46	.02
Slope	-1.58 (0.22)	[-2.01, -1.15]	-7.26	< .001
Covariance	-0.04 (0.04)	[-0.12, 0.04]	-1.07	.29

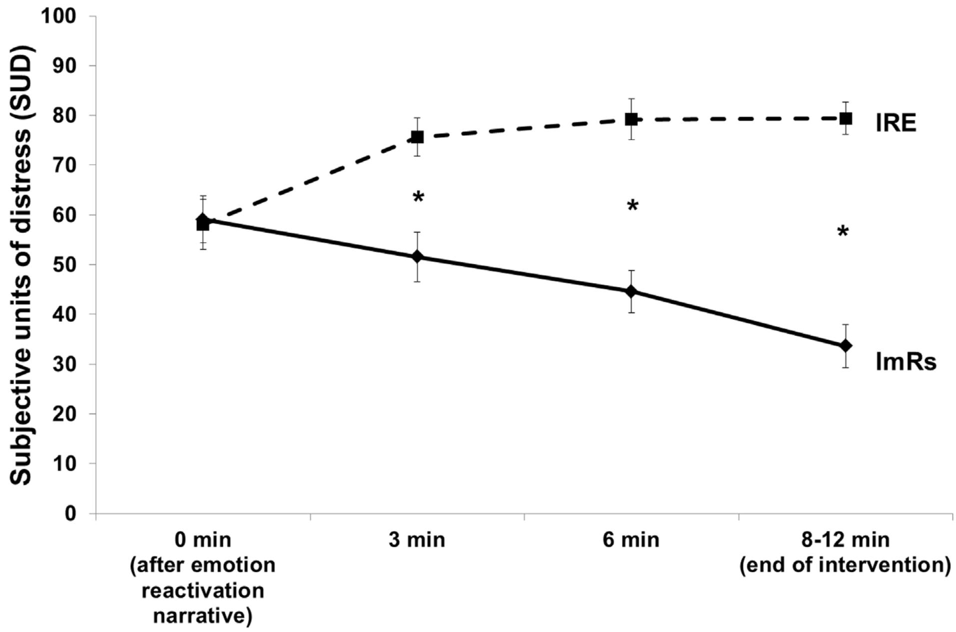

Fig. 2. Subjective units of distress (SUD) during imagery rescripting (ImRs) and imagery rehearsal (IRE).
$^*p < .001$.

3.3. Emotions following the intervention (hypothesis 2)

Repeated measures ANOVAs using Bonferroni-adjusted alpha levels of .006 per test ($\alpha = .05/9$) revealed significant Time × Condition interaction effects for all VAS, PANAS-NA, and PANAS-PA, $Fs > 5.83$, $ps < .005$, $\eta_p^2s > 0.12$. Post-hoc tests indicated that participants in ImRs, IRE, and NIC did not differ in emotions and affect prior to the intervention ($Fs < 1.16$, $ps > .32$, $\eta_p^2s < 0.03$), but differed significantly in PANAS-NA and emotions after the intervention, $Fs > 6.26$, $ps < .003$, $\eta_p^2s > 0.13$. After correcting for multiple tests (Bonferroni-adjusted alpha of .002, i.e., $\alpha = .05/(9 \times 3)$), participants in ImRs showed lower levels of several fear (anxiety, horror; $ps < .001$) and non-fear emotions (anger, disgust; $ps < .002$) when compared to IRE after the intervention. However, ImRs and IRE did not significantly differ in shame, guilt, sadness, and PANAS-NA ($ps > .002$). After the intervention, participants in ImRs did not differ from participants in NIC in anxiety, horror, sadness, shame, and guilt ($ps > .002$), but did significantly differ in PANAS-NA, anger, and disgust ($ps < .002$) with higher levels in ImRs. IRE and NIC differed significantly in PANAS-NA and all emotions ($ps < .002$) except for guilt ($p = .004$). No difference between the groups could be found in PANAS-PA after the intervention, $F(2, 85) = 1.67$, $p > .19$, $\eta_p^2 > 0.04$ (for graphs, see Fig. A1 in the Supplementary material).

3.4. Intrusive memories (hypothesis 3)

A univariate ANOVA did not yield any group differences in the number of intrusive memories of the aversive film prior to the intervention, $F(2, 85) = 1.38$, $p = .26$, $\eta_p^2 = 0.03$, see Fig. 3a. Contrary to expectations, ImRs[1] and IRE did not differ from NIC regarding the total number of intrusive memories during the week following the intervention, $F(2, 85) = 0.71$, $p = .50$, $\eta_p^2 = 0.02$; Fig. 3b. Similarly, conditions did not differ regarding the number of participants who did not experience any intrusive memories at baseline ($n_{total} = 8$; $\chi^2(2) = 0.25$, $p = .88$, $V = 0.05$) or post-intervention ($n_{total} = 20$; $\chi^2(2) = 0.40$, $p = .82$, $V = 0.07$).

Multilevel analyses on the course of intrusive memories over time showed that the intercept differed significantly between ImRs and NIC (Table 1). However, even after controlling for a possible baseline effect, the number of intrusive memories decreased significantly faster in ImRs than in NIC (Fig. 4). No significant differences were found between ImRs and IRE, or between IRE and NIC.

3.5. Exploratory analyses

Univariate ANOVAs revealed no differences between the three groups on distress, vividness, controllability of intrusive memories ($Fs < 2.22$, $ps > .12$, $\eta_p^2s < 0.07$), or the IES-R subscales: intrusions ($F(2, 85) = 1.12$, $p = .33$, $\eta_p^2 = 0.03$), avoidance ($F(2, 85) = 0.11$, $p = .90$, $\eta_p^2 = 0.002$), and hyperarousal, $F(2, 85) = 0.22$, $p = .80$, $\eta_p^2 = 0.01$. The number of correct answers on the explicit memory recall test ranged between 6 and 12 (ImRs: $M = 9.76$, $SD = 1.41$; IRE: $M = 9.97$, $SD = 1.24$; NIC: $M = 9.50$, $SD = 1.57$) and did not differ between conditions, $F(2, 85) = 0.80$, $p = .45$, $\eta_p^2 = 0.02$.

4. Discussion

The present study examined the effects of a 10 min ImRs intervention on consolidated emotional memories of an aversive film comparing ImRs to IRE and NIC within a multiple-day TFP study. In contrast to previous studies, which mainly focused on preventive effects of ImRs during memory encoding and/or consolidation (e.g., Dibbets & Arntz, 2016; Hagenaars & Arntz, 2012; Seebauer et al., 2014), the current study design allowed for the examination of therapeutic effects of ImRs on *consolidated* memories. Therefore, this study design can be regarded as a better laboratory analogue for the way in which ImRs is typically used in psychological treatment. In line with our hypotheses, results suggest that ImRs was experienced as less distressing than IRE and elicited less negative fear and non-fear emotions in the short-term when compared to IRE, underscoring possible advantages of ImRs over

[1] Within the ImRs condition we additionally tested for differences between participants with different individual hotspots (*rape* or *beating*) as well as with different numbers of repetitions of the ImRs script. No group differences for the different hotspots or the different number of repetitions emerged with respect to the total number of intrusive memories at baseline or between session 2 and session 3 (for additional statistical analyses, see Table A.2 in the Supplementary material).

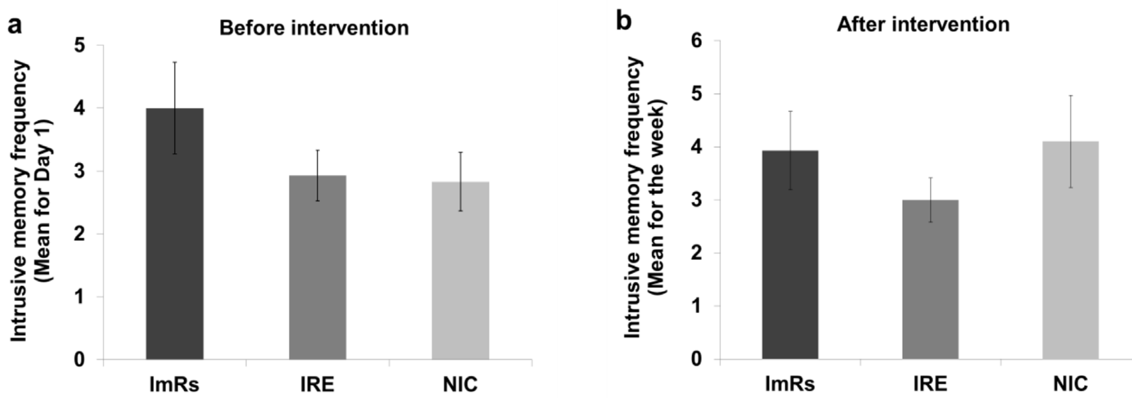

Fig. 3. (a) Intrusive memory frequency per group during the first 24 h following the aversive film and (b) during the week following the intervention (or NIC).

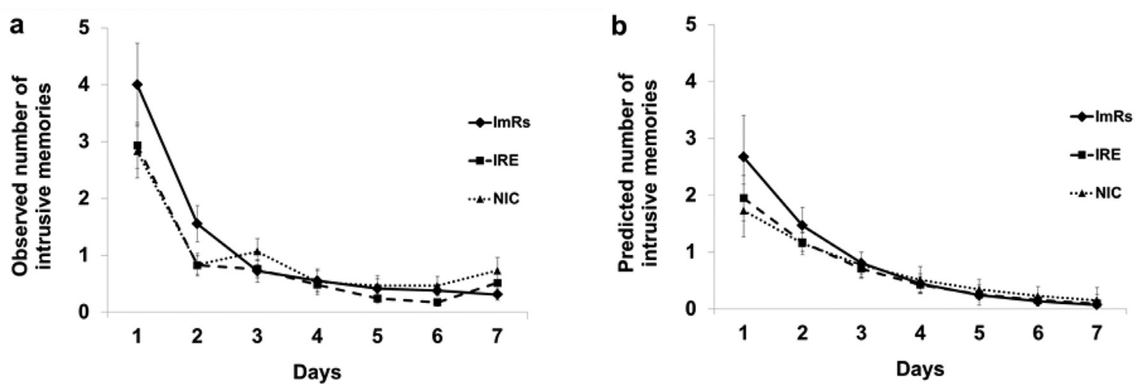

Fig. 4. (a) Observed number of intrusive memories. (b) Predicted number of intrusive memories in the multilevel Poisson regression model.
Days are defined as individual 24 h-time-windows with Day 1 representing intrusive memories that occurred between the end of session 1 and the beginning of session 2 (i.e., before the intervention). Day 2 includes intrusive memories occurring within 24 h after session 2 (i.e., after the intervention).

exposure-based treatments. Contrary to our hypothesis, ImRs and IRE did not differ from NIC with respect to the total number of intrusive memories of an aversive film clip. However, ImRs accelerated the decline of the intrusive memories.

The unanticipated finding that ImRs and IRE did not differ from NIC on the number of intrusive memories may point to procedural limitations of the multiple-day TFP used in this study: Even though ImRs has been proven to be effective in clinical studies, we may not yet be able to properly model the clinical effects of this complex intervention in a laboratory setting. Thus, the results highlight the necessity to further improve the analogue ImRs intervention for future studies. Furthermore, examining the reported numbers of intrusive memories on a day-by-day basis revealed that about 50% of the intrusive memories occurred before the intervention was conducted. Within the six days following the intervention, participants in each condition reported a total of only three to four intrusive memories, indicating that experimentally induced intrusive memories declined quickly. It is conceivable that due to this floor effect we were not able to detect potential effects of the interventions on intrusive memories when compared to NIC. Although the multiple-day TFP appears very useful to systematically examine the efficacy and mechanisms underlying ImRs with regard to distress and negative emotions in an analogue setting, its suitability to investigate therapeutic effects regarding intrusive memory frequency may be limited, unless a different film is used that leads to a higher number of intrusive memories experienced beyond Day 1. Nevertheless, the present findings provide preliminary evidence that a brief ImRs intervention may lead to faster symptom recovery than no intervention within an experimental study design. However, due to the aforementioned floor effect these findings should be interpreted with caution.

Given that this study was one of the first to experimentally investigate the effects of ImRs on consolidated memories, we conducted several exploratory analyses. First, no difference between conditions was found regarding the distress, vividness, and perceived controllability of the intrusive memories. The latter result is surprising in light of previous findings by Kunze, Lancee, Morina, Kindt, and Arntz (submitted), who assessed mediators of ImRs and IE in patients with nightmare disorder ($N = 104$) and found that enhanced mastery of the nightmare content mediated the efficacy of ImRs. However, in the present study we did not explicitly instruct participants to imagine themselves as being actively involved in the rescripted storyline; therefore, the study may have been limited by its ability to manipulate beliefs about personal capabilities (e.g., mastery). In order to investigate such processes, future research should use experimental paradigms that enable the examination of personally more relevant memories (e.g., autobiographical memories; Çili, Pettit, & Stopa, 2016).

Second, we did not find differences between the conditions on explicit memory recall, even though memory updating mechanisms during reconsolidation may play a crucial role in ImRs (Arntz, 2012; Brewin, 2006). On the one hand it has been suggested that ImRs may lead to the formation of a new, more positive memory representation which then competes with the old, distressing memory at retrieval (Brewin, 2006; Brewin Gregory, Lipton, & Burgess, 2010). On the other hand, Arntz (2012) proposes that ImRs may change the meaning of the original trauma memory representation. It is currently unclear whether the therapeutic changes brought about by ImRs are only reflected in the emotional part of the memory or whether the rescripted storyline is also integrated (at least partly) into declarative memory. Empirical data on this topic is currently lacking and clearly warrants further investigation as it may have significant consequences (e.g., for patients, who still have to testify in court following a crime). However, preliminary findings suggest that compared to a trauma-irrelevant positive imagery task, ImRs even may enhance declarative memory recall (Hagenaars & Arntz, 2012). Likewise, the present results showed that participants in all three conditions did very well on the explicit memory test (79–83% correct answers), indicating that ImRs (or IRE) does not have detrimental effects on the factual details of the memory.

The multiple-day TFP used in this study proved to be sensitive to investigate the comparative efficacy of ImRs on perceived film-related distress and negative emotions. Even though we did not explicitly investigate working mechanisms underlying these effects in the current study, the multiple-day TFP provides a promising paradigm for this purpose in future research. Although we assume that the procedure used in this study allowed us to tap into memory updating processes (e.g., James et al., 2015), we were not specifically able to test whether ImRs disrupted the reconsolidation of the original memory as suggested by Arntz (2012), or whether ImRs facilitated the formation of a new memory representation as proposed by Brewin and colleagues (Brewin, 2006; Brewin et al., 2010). In order to test these competing hypotheses about the memory processes underlying ImRs, future research should compare the procedures used in session 2 for memory reactivation and the induction of reconsolidation to control conditions without memory reactivation. Specifically, comparing conditions with and without memory reactivation would allow to test whether reconsolidation is triggered by the memory reactivation task used in this study. Additionally, in order to validate whether the memory reactivation task is a sufficient procedure to induce a prediction error, future research should include expectancy ratings. Furthermore, combining the multiple-day TFP with Pavlovian fear-conditioning (see Kunze, Arntz, & Kindt, 2015) could allow for the examination of specific memory processes underlying ImRs.

The present study has several limitations. In order to increase comparability between ImRs, IRE, and NIC, the time frame for the interventions was standardized, which might have decreased the efficacy of ImRs as an imagery-based treatment and IRE as an exposure-based intervention. Furthermore, the study included a sample of healthy, highly educated, young females. Therefore, the results cannot be generalized to patient populations or more heterogeneous samples regarding gender, age, or education.

In conclusion, adding to our general understanding of ImRs, the results highlight that (1) ImRs is experienced as less distressing than an exposure-based intervention (IRE) and (2) ImRs elicits less negative fear and non-fear emotions on the short-term compared to IRE. However, (3) previous findings indicating a superiority of ImRs over NIC in reducing the number of intrusive memories could not be replicated. Nevertheless, our results yield first evidence that (4) ImRs may accelerate the recovery process of intrusive memories after the experience of an aversive event at least within an experimental study design. The results suggest that a multiple-day TFP can be used to investigate the efficacy and working mechanisms of ImRs with respect to short-term distress and emotions. However, its suitability to investigate therapeutic effects regarding intrusive memory frequency appears to be limited due to a floor effect. In sum, this study adds to the current literature on ImRs as a psychological intervention in the treatment of emotional memories. Despite the obvious limitations of analogue experimental designs, the promising clinical effects of ImRs strongly suggest that it is worthwhile to further investigate this transdiagnostic treatment method in order to eventually improve its clinical effectiveness.

Declaration of interest

The authors declare that they have no conflict of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jbtep.2018.08.007.

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