Implanting False Autobiographical Memories for Repeated Events

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Abstract

Research to date has exclusively focused on the implantation of false memories for single events. The current experiment is the first proof of concept that false memories can be implanted for repeated autobiographical experiences using an adapted false memory implantation paradigm. We predicted that false memory implantation approaches for repeated events would generate fewer false memories compared to the classic implantation method for single events. We assigned students to one of three implantation conditions in our study: Standard, Repeated, and Gradual. Participants underwent three interview sessions with a 1-week interval between sessions. In the Standard condition, we exposed participants to a single-event implantation method in all three interviews. In the Repeated condition, participants underwent a repeated-event implantation method in the three interviews. The Gradual condition also consisted of a repeated-event implantation method, however, in the first interview alone, we suggested to participants that they had experienced the false narrative once. Surprisingly, within our sample, false memories rates in the Standard condition were not higher compared to the Repeated and Gradual conditions. Although sometimes debated, our results imply that false memories for repeated events can be implanted in lab conditions, likely with the same ease as false memories for single events.

Keywords: false memory implantation, repeated events, adults' memory

Implanting False Autobiographical Memories for Repeated Events

For over 25 years, researchers have examined how people can form rich false episodic memories in suggestive therapeutic or investigative interview contexts (Loftus & Pickrell, 1995; Scoboria et al., 2017). Research on false memory formation for autobiographical events is relevant for cases in which suggestive psychotherapeutic practices may have fostered false memories of child sexual abuse (see Maran, 2010; Lindsay & Read, 1994; Scoboria et al., 2017). False memories likely form the basis of only a small proportion of sexual abuse cases in the courtroom, but they are highly detrimental to the justice system. These cases can waste substantial public resources in costly and prolonged forensic investigations, leading to false accusations and potential miscarriages of justice (Loftus, 2005; see: Maran, 2010).

Some critics have aptly noted that victims of sexual abuse often experience and recall multiple episodes of abuse, rather than a single one (Brewin & Andrews, 2017; Blizard & Shaw, 2019). However, to date, no experimental studies have demonstrated the implantation of false autobiographical memories for repeated events, and as such, the existing literature may be limited in this important aspect. Here, we present the first study attempting to implant false autobiographical memories for repeated events.

False Memory Implantation

To investigate whether false memories for entire autobiographical events could be implanted experimentally, Loftus and Pickrell (1995) designed the now-classic “lost-in-the-mall” paradigm. In their study, the experimenter collected narratives of episodes from the participants’ family that happened during participants’ childhood. Participants were asked to report everything they could remember about these events. Unbeknownst to them, one event never happened (i.e., being lost in a shopping mall or big department store) and was actually manufactured by the researchers. In studies using this paradigm, a non-trivial percentage of

participants claim to have experienced this false event (on average, around 30%; Scoboria et al., 2017). However, as critics have pointed out, these studies have only focused on the implantation of single events (see Table A1 for an overview of false memory implantation studies using adult participants). Critics such as Blizard and M. Shaw (2019) have noted that false memory researchers have not “been able to implant memories for repeated events, as is often the case with reported childhood sexual abuse” (p. 15). Similarly, Brewin and Andrews (2016) stressed that, “A challenge for the future will be to demonstrate that it is possible to implant memories of a repeated event” (p. 20). Clearly, an experimental demonstration of implantation of autobiographical false memories for repeated events is necessary to address these limitations of the existing literature.

Indeed, implanting false memories for repeated events may be more difficult than single events. Metacognitive processes might inhibit the formation of false memories for repeated events. That is, people may doubt that a suggested episode happened to them repeatedly, without them having any script (as per schema theory; Farrar & Goodman, 1992) or gist trace (as per fuzzy trace theory; Brainerd & Reyna, 2012) about the event. Consequently, people would reject the suggestion of having experienced a repeated false event. Associative activation theory posits that when a certain experience repeats itself, a script (i.e., the cluster of typical activities that occur during an event) of this experience is created containing details that are strongly interconnected with each other (Howe et al., 2009; Otgaar et al., 2019). Additionally, having a script concerning a suggested event has been shown to facilitate the formation of implanted false memories (Otgaar et al., 2010; Pezdek et al., 2006).

What is known about false memories for repeated events comes from studies focusing particularly on the changes in specific instances of repeated occurrences for a real event (e.g., Connolly & Price, 2006; Connolly et al., 2016; Connolly, 1997; Price et al., 2006). Here, the

main finding is that children who repeatedly experienced an event were more susceptible to false suggestions regarding details of these events than children who experienced the same event only once (e.g., Price & Connolly, 2004). The explanation for this finding is that when people experience an event repeatedly it will be more difficult to retrieve the exact details of a specific event. In this situation, people will rely more on the gist (underlying theme) of an event, which might consequently make them prone to false memory creation (e.g., Brainerd & Reyna, 2012). Nevertheless, these studies cannot be applied to implantation of entire autobiographical events. However, such body of research, contributes to the understanding that if one does rely mostly on the gist of a group of memories concerning a repeated event, one would likely be skeptical of an event they have supposedly experienced repeatedly without having any gist for it.

The Current Experiment

To directly address criticisms of past work, in the current experiment, we adapted the lost-in-the mall paradigm and examined (1) whether rich autobiographical false memories for repeated events could be implanted; (2) whether implantation of false memories for repeated events would be easier or more difficult compared to single events; and (3) whether familiarization with the event, prior to the suggestion that it occurred repeatedly, would facilitate implantation of false memories for repeated events.

We examined two approaches to implanting false memories for repeated events. Two of our experimental groups received false suggestions that a childhood event happened repeatedly to them. In one group, in all three interview sessions, participants received the suggestion that the false event happened to them repeatedly. Almost the same procedure was followed in the other group, except that we told participants in the first session that the event happened once, before suggesting to them it happened repeatedly during sessions two and three. Our aim was to examine whether implantation for repeated events could be facilitated

if we first established some familiarity for the false narrative before increasing the frequency for the event occurrences. As suggested by Mazzoni and Kirsch's (2002) metacognitive model, establishing such familiarity might contribute to the formation of a script of the false event, thereby promoting false memory production (see also Ost et al., 2007). We predicted that it would be more difficult to implant false memories for repeated events than for single ones. Additionally, we expected that familiarization with the false narrative would facilitate the implantation of false memories for repeated events.

Method

We preregistered the methods and materials for the present study on the Open Science Framework (OSF). Before data collection was complete and prior to data analysis, we updated the registration to offer better-specified hypotheses and corresponding statistical tests, since our initial registration was not sufficiently detailed about the statistical approach to testing the predictions. Two additional registrations were made to update the randomization procedures (i.e., to rebalance the groups after data exclusions) and to update the data coding procedures. These updates were created prior to data analysis. All this information and supplementary materials are available here:

https://osf.io/4fzht/?view_only=cf0035032a124786b7ccce67ec60e43c.

Participants

We determined in advance that we would recruit participants until we reached a target sample size of $N = 120$ participants with usable data. We based this target on what we considered feasible given available time and resources. Additionally, to the best of our knowledge, the present study uses the largest sample in the literature on false memory implantation (see Table A1). With three measurements per participant ($N = 360$ observations), a sensitivity analysis suggested that this sample size provides .80 power to detect effects of f^2

= .03 ($d = .32$), assuming a conventional alpha level of .05. For this calculation we used the pwr package (Champely, 2018) for R (R Core Team, 2018).

We recruited a total of 245 students from one of the universities associated with this project and students from a Music Conservatorium in the Netherlands. Our participants came from a variety of countries and ranged between 18 and 36 years of age (see Appendix A for more demographic information about our participants). Participants were excluded if they were found to (1) have experienced our false narrative (this was checked with participants' parents); (2) be out of the age range of 18-36 years old (this was assessed via our prescreening demographic questionnaire); (3) be currently enrolled in the 3rd year of the psychology bachelor's, master's, or doctorate programs at University X (also assessed via prescreening demographic questionnaire); (4) have spoken to family and friends about narratives used in the study during testing phase (asked participants in the debriefing phase of the study); or (5) have participated in other false memory implantation studies at University X (this was checked via email with participants in the prescreening phase). In addition, some parents did not provide childhood stories for some of our participants, which invalidated the continuation of their participation in the study. Some participants did not respond to our emails to schedule their interview sessions and consequently did not participate in the study.

In total, 125 participants were excluded. With the exception of one participant, these exclusions took place in the prescreening phase. The exception was a participant who told us during the testing phase that his housemate had also participated in our study and had told him the real intent of the project. These exclusion criteria were in place to ensure that (1) the suggested narrative was indeed a false narrative for each participant, (2) the suggested narrative would have taken place at a reasonably similar amount of time in the past for each participant, (3) the participants were less likely to have received relevant education about false memory phenomena, (4) the participants did not discover that the suggested narrative

was false during the testing period, and (5) the participants had not been exposed to similar procedures. After exclusions, the final sample size was $N = 120$ participants. Participants were rewarded in the end of the final interview session with a voucher of €15 or academic credits for their participation. This study was approved by the standing ethical committee of University X.

Design

We used a 3 (Implantation Method: Standard, Repeated, and Gradual; between subjects) x 3 (Time: Interview 1, Interview 2, Interview 3; within subjects) mixed design. Participants were randomly assigned to one of the three different groups (Standard $N = 40$; Repeated $N = 41$; Gradual $N = 39$). Participants in the Standard and Repeated groups heard from the interviewer consistently, from the first to the third interview session, that they had experienced the false narrative (and their true experiences) in a given fixed frequency, once or more than once. However, participants in the Gradual group heard in the first interview session that the false narrative (and true experiences) had occurred to them once, and in the second and third interview sessions, the interviewer suggested all childhood stories (false narrative included) had actually happened more than once.

Procedure

Figure 1 provides a diagram of the procedures. We advertised our study as “Childhood Memories”, stating that we were interested in learning how good people’s memory for their childhood experiences could be. Students who were interested in participating in our study, contacted us via email and receive a link to an online demographic questionnaire. After we received their demographic information, we randomly assigned them to one of the three experimental conditions. Randomization at this point was necessary because the screening procedure varied by condition. Specifically, we contacted participants’ family to collect either stories of childhood events that happened once (for the Standard

condition) or several times (for the Repeated and Gradual conditions). In order to collect true stories from participants' childhood, as well as to check whether our false narrative had happened to them, we contacted the family member participants nominated in their demographic questionnaire by email or phone. In the majority of cases, participants indicated their parents (97.5%); only 1 participant indicated their brother and mother; and 2 participants indicated their sisters.

Figure 1

Experimental Procedure

The 8 interviewers in this study were students from the Legal and Forensic Psychology Master's programs at University X who worked on our project for their master's thesis. For this reason, they were aware of all hypotheses and design of the experiment. They

were trained in the course of 40 hours spread over two weeks to become familiar with the interview script that should be followed strictly to avoid excessive differences between interviewers. We trained the interviewers so that they could conduct interviews of all three experimental groups.

All participants underwent three interview sessions that were audio recorded, with a one-week interval between each session. The debriefing phase happened at the end of the third session. In the interview sessions, the experimenter told the participant that their parents had reported to us that all narratives had taken place in the participant's lives between the age of 5 and 10 years old. For all three interviews, the childhood stories were told in the following order: (1) true story; (2) true story; (3) false story; (4) true story. Specifically, for the false narrative that only happened once we told participants the following: *"So, your mum told us that when you were a child you lost one of your favorite cuddling toys. It was an elephant that you really liked. According to your mum, it was very hard for you to lose this toy, you got really sad and cried a lot. Tell me what you remember about this event"*. For the repeated conditions, we told participants: *"So, your mum told us that when you were a child, it happened to you more than once that you lost one of your favorite cuddling toys. It was an elephant that you really liked. According to your mum, it was very hard for you to lose this toy, you got really sad and cried a lot. This happened to you more than once. Tell me what you remember the most about the times this happened"*. In this example we refer to the participants mother, but this was adapted accordingly to the relative participants had referred to us.

Interview 1

The interview setting was consistently a quiet, simple room with two chairs and one table. After participants were welcomed to the interview setting, the interviewer explained to them the supposed aim of the study using our cover story. The interviewer reminded

participants that all three interview sessions would be voice recorded for data collection purposes, additionally the interviewer handed to participants the study information letter and informed consent. Subsequently, the interviewer told participants that the research team had contacted their families in order to collect childhood episodes that had happened to them. For those in the Standard group the interviewer narrated the events, explaining to participants that each event had “*happened to them*” and asking them to say everything they could remember from that occurrence. This specifically implied that the events had only happened once. In the Repeated group, participants were informed that the family member who provided the narratives attested that all of the narrated events had happened more than once. As for participants in the Gradual group, they also learned that the events “*happened to them*”, the same as the standard group.

In line with past studies (displayed in Table A1), whenever participants presented any difficulty in retrieving any of the episodes, we encouraged them to try to remember again. Additionally, the interviewer told participants that it is common to not remember certain events that happened a long time in the past. After this, if participants still could not remember the given experience, we used context reinstatement (re-establishing mentally the environment and emotional state) and guided imagery techniques (Goff & Roediger, 1998; Lindsay & Read, 1994), as previous studies have. At the end of the first interview, we encouraged participants to think about the events we had presented them with. The interviewer also asked them not to talk to anyone about the experiment and the stories they were trying to recall.

Interview 2

In the second interview we narrated verbatim to participants all the same four stories they had heard in Interview 1. For both the Standard and Repeated group, we kept the frequency of the stories the same as interview 1: single events for the Standard group and

repeated events for the Repeated group. Differently from these groups, in the second interview, the Gradual group's frequency of the events changed compared to the first interview of the same group. That is, we told participants in the introduction of the interview session: "Last week I told you about four events that your mother¹ told us that you have experienced a few times when you were around the age of 5 to 10 years old. It turns out, that there's a really high chance that they happened to you more than once. As I said last week, I am particularly interested in what you can remember of those events compared to your mother's report. Hopefully you could remember more details throughout the week. So, I'm going to read you those events all over again and after reading them, I ask you to tell me everything you can remember. Do you understand? Ok, then we're going to start now."

For all groups, interviewers applied the same procedure of context reinstatement and imaginary inflation also used in Interview 1 when necessary. At the end of the session, the interviewer encouraged participants to think about all the stories presented to them. We also asked participants not to talk to anyone about the experiment and think about the experiences they had not been able to recall.

Interview 3

For all three groups, the third interview followed the same steps as the second interview. At the end of this session, participants were debriefed about the true nature of the study. Interviewers asked participants if they could guess which of the four stories, they had heard in the experiment, was actually false.

Materials

True Narratives

¹ We used mother as an example, but it could have been any family member indicated by participants as their contact person.

We collected three truly experienced stories from participants' families. Specifically, for participants assigned to the Repeated and Gradual group, recurrent childhood experiences were collected; for participants allocated in the standard group, we gathered childhood events that only happened once. All of the collected childhood events should have happened to the participants between the age of 5 and 10 years old to keep it consistent with the same time frame we had chosen for our false narrative.

False narrative

To find a suitably plausible negative experience to falsely suggest in our experiment, we conducted a pilot study ($N = 20$) with co-workers from University X to examine 10 different possible events to be used in our study (https://osf.io/4fzht/?view_only=cf0035032a124786b7ccce67ec60e43c). These events were used in the literature in previous research (see Table A1). We asked participants to score each of the 10 different narratives from 1 to 7 in terms of plausibility (1 = not plausible, 7 = extremely plausible), and emotional valence (1 = positive, 7 = negative). The events available for participants to assess included events such as being lost in a shopping mall and going on a hot air balloon ride which have been used in previous research (e.g., Loftus & Pickrell, 1995; Wade et al., 2002). For ethical reasons, we aimed for a childhood experience that could be adapted for both the Repeated and Standard group rated as negative, but not extremely negative (scoring from 5-6). Furthermore, as we hypothesized that it would be more difficult to implant false memories for repeated events (see Hypothesis subsection), we hoped to improve the implantation rates by choosing a plausible or extremely plausible event (scoring from 5-7).

Pilot participants rated "losing a toy" as the most plausible ($M = 6.85$, $SD = 0.36$) event combined with moderately negative valence ($M = 5.37$, $SD = 1.38$). Based on this, we created the following false narrative: Between the age of 5 and 10 years old, to have lost an

elephant cuddly toy (stuffed animal), to be very upset about it, and to cry a lot. For situations in which participants did not indicate a location in which the event might have occurred, we created three possible scenarios in which this event could have happened for the interviewers to suggest. Specifically, interviewers suggested that participants could have lost their elephant in a park, in school, or in a supermarket. Participants in the Repeated and Gradual groups were told they had lost the elephant several times, each time recovering the toy, until they lost it for good.

Autobiographical Belief and Recollection Ratings

After the presentation of a true or false narrative, participants received a questionnaire, in which they could rate their own recollection and belief for the events on a scale from 1 (“I do not recall this event” or “this did not happen to me”) to 8 (“I remember this event completely” or “I am completely confident that this happened to me”; see Otgaar et al., 2013; Scoboria, Mazzoni, Kirsch, & Relyea, 2004). Specifically, for each narrative, participants rated their recollection and belief separately. We explained to participants that by recollection they should consider any mental images that occurred to them concerning each narrative, and for belief we explained we wanted to know how confident they were of experiencing the narratives.

Researcher Coding

In addition to participant’s self-scoring, we used Scoboria and colleagues (2017) approach to coding the content of the false narratives. This coding takes under consideration both belief and recollection for false memories. We adapted the rating form for participants in the Repeated and Gradual by adding extra questions and duplicating some of the original questions from Scoboria et al. (2017). We elaborate on the coding procedures in the following subsections. The complete research rating instrument is available at

https://osf.io/4fzht/?view_only=cf0035032a124786b7ccce67ec60e43c.

Memory and Belief Quality in the Repeated and Gradual Conditions

Participants (self-rating) in the Repeated and Gradual groups, who had up to three occurrences of the false narrative to report, ranked each occurrence from most to least vivid and believed. In the self-report, the first scored occurrence of the false event corresponded to their first most vivid and believed occurrence. They then rated their second most vivid and believed occurrence, and finally their third most vivid and believed occurrence. Researcher also followed this system when assessing participants memory statements and coding the researcher coding instrument.

Hypotheses

We had three hypotheses:

(1) Acceptance and false memory rates for the Standard group were expected to be similar to the rates presented at Scoboria and colleagues' (2017) mega-analysis for the same dependent variables (Acceptance = 69.7% and False Memory = 30%). Using a chi square test, we compared our results for the rates of acceptance and false memories to those obtained in the general literature, to ensure that our results in the Standard group were comparable to past false memory implantation attempts.

(2) We predicted that inducing participants to believe and recall the false narrative in a repeated occasion format would be more difficult, compared to a single occasion format. That is, we expected that both participants' self-reports and researcher ratings would show that belief and recollection for the false narrative would be lower in the Repeated and Gradual conditions compared to the Standard condition of this experiment. To test this prediction, we used linear mixed effect models to compare data for belief and recollection for the false narrative from Repeated and Gradual groups with the Standard group across three interviews. We used this statistical approach for both participants' self-reports and researcher ratings.

(3) We predicted that the gradual introduction of suggestion of a false narrative would facilitate a more effective implantation compared to suggesting the false event occurred repeatedly from the outset. Therefore, belief and recollection for the Gradual group would be higher than those in the Repeated group. In the Gradual group we attempt to create familiarity with the false narrative before introducing the frequency in which it happened. The linear mixed effect models described above also provide the comparison of false beliefs and false memory rates for the Repeated and Gradual groups.

Coding and Analysis

Researcher rating

Our 8 researcher who interviewed participants, coded their data after every interview within following the same coding system as in the mega-analysis of previous false memory implantation studies by Scoboria et al. (2017). As can be seen in Table 1, the coding used in Scoboria et al (2017) only shows one variable that purely measures the rates of belief, and 3 measures for recollection. In addition to coding the variables displayed in Table 1, we coded several exploratory variables (not reported here, in the interest of space), similar to those measured by Scoboria et al. (e.g., emotional content of the narrative).

Table 1

Variables Used to Measure False Memory Rates in Scoboria et al (2017)

Item	Variables	Scale
1- Acceptance	1- Participant's acceptance of the specific details of the false event that were provided to them	0- Outright rejection; 1- Minimal acceptance/accept parts, reject parts; 2- Moderate acceptance/acceptance with no active rejection; 3- Complete acceptance.
2- Elaboration	2- Information given by participants beyond what was	No/Yes

provided to them		
	3- Elaboration amount	1- Minimal; 2- Moderate; 3- Substantial
3- Imagery	5- Sensory imagery generated by participant	No/Yes
	6- Amount of sensory imagery generated by participant	1- Small amount of imagery (about 1 image); 2- Moderate amount of imagery (about 2–4 images); 3- High amount of imagery (about 5 or more images)
4- Event Rejection	7- Whether participant verbally state they did not have a memory for the false narrative	No/Yes

Because we were interested in repeated events, we measured our variables at the level of each occurrence of the false event (i.e., up to three occurrences) within each interview (i.e., three interviews). Simple direct statements such as “*I remember this happened to me*” were not sufficient for us to conclude a participant had formed false memories for the false narrative. Rather, when scoring the data, we examined their statements in full, as other elements might indicate whether a false memory was formed, such as elaborating on details (e.g., “*I remember it was raining that day*”; “*The park was full of children when we were there*”). We used the same false memory categories as Scoboria et al (2017) to classify participants’ coded statements. The categories are as follows: robust false memory, full false memory, partial false memory, accepted false memory, no false memory, and rejected false memory. Table A2 provides descriptions of each false memory category.

For a participant's memory report to qualify as robust false memory there had to be present a high level of acceptance, and moderate level of elaboration, and imagery. To be classified as full false memory, results had to meet moderate level of acceptance, elaboration,

and imagery. For the partial false memory category, we considered results displaying moderate level of acceptance with any level of elaboration and imagery. To qualify as accepted false memory, results had to show solely moderate level of acceptance. To be coded as no false memory, there had to be any level of acceptance, with the absence of any scoring in the other two items (i.e., elaboration and imagery). Finally, a participant's result could qualify for rejected false memory, when no level of acceptance with the absence of the other two items were presented (i.e., elaboration and imagery).

Inter-Rater Reliability

To perform our interrater reliability coding, we trained (20 hours) two professional research assistants who were blind to the hypothesis of the study. We instructed them to code all interview sessions in the same fashion that the 8 interviewers did. The inter-rater coders studied the coding system used in Scoboria et al. (2017). The 2 inter-rater coders had access to both the transcripts and audio of the interview sessions to fill in the “researcher coding forms”.

We used the data corresponding to 42 (35.8%) participants² selected randomly to calculate the inter-rater reliability for the researcher’s rating. As index of agreement between the two raters for the false memory category coding, we used Gwet’s AC with linear weights for the ordinal categories (Gwet, 2008). Gwet’s AC results can be interpreted in a manner similar to Cohen’s kappa. The levels of inter-rater reliability displayed in Table 2 indicate that the agreement between the two raters coding varied from moderate to high agreement (Gwet, 2008).

Table 2

² Out of 118 participants whose researcher rating data we had available, sound files corresponding to two participants got corrupted and could not be accessed by the inter-rater reliability coders. Since the interviewers had access to both the transcript and audio of participants to code their memory reports, we decided to restrict inter-rater reliability analysis to 118 participants instead of 120.

Inter-Rater Reliability for Researcher Coding

Variable	Gwet's AC	95% CI
Participant's acceptance of the specific details of the false event that were provided to them	0.52	0.44, 0.59
Information given by participants beyond what was provided to them	0.71	0.63, 0.80
Elaboration amount	0.57	0.33, 0.81
Sensory imagery generated by participant	0.63	0.49, 0.76
Amount of sensory imagery generated by participant	0.64	0.37, 0.67
Whether participant verbally state they did not have a memory for the false narrative	0.78	0.72, 0.85

Results**Summary**

Given the quantity and depth of the data produced by the present study, we begin with a brief narrative summary of the results, followed by formal statistical analyses. To provide a straightforward summary, we can assess the formation of false memories using the coded statements participants provided in the interviews. In the Standard condition, 25.64% (10/39) of participants provided a statement, in at least one of the three interviews, classified as a partial, full, or robust false memory. Thus, it appears that a non-trivial minority of participants formed false memories for the suggested event. However, contrary to our expectations (Hypothesis 1), this rate was lower than the overall rate found in the literature (see below; Scoboria et al, 2017).

In the Repeated condition, 34.14% (14/41) of participants formed false memories (by this operationalization), and of those, 14.28% (2/14) provided more than one such statement within a single interview, indicating false memories for repeated events. In a similar pattern,

36.84% (14/38) of participants in Gradual condition formed false memories, and of those, 28.57% (4/14) formed false memories for repeated events. Although the rate of false memory formation for repeated events was relatively low, suggesting that the target event occurred more than once did not decrease the overall rate of false memory formation, counter to our expectations (Hypotheses 2 and 3). These results are corroborated by participants' self-reports (see below).

In the Standard condition, 76.92% (30/39) of participants provided at least one statement indicating acceptance of a false memory for the suggested event. By this measure, participants in the Repeated (75.61%, 31/41) and Gradual (81.57%, 31/38) conditions accepted at least one occasion of the suggested event at similar rates. A substantial minority of participants in the Repeated (24.39%, 10/41) and Gradual (36.84%, 14/38) conditions provided more than one statement within a single interview that indicated at least acceptance of the event, suggesting false beliefs for repeated events (see Table C3).

In short, suggesting the false event happened repeatedly (either from the outset of the interviews or gradually) led to some participants believing and/or remembering that they experienced the event several times, without reducing the overall rate of false memory formation as we had expected. The present study demonstrates the feasibility of implanting false memories for repeated events.

Overview of Statistical Results

Three dependent variables provided information about participants' formation of false memories: (1) self-reported recollection of the false event, (2) self-reported belief that the false event occurred, and (3) researcher-coding of participants' recorded narratives for indications of false memories. Additionally, in the Repeated and Gradual groups, we refer to the quality of false recollections in terms of "vividness". Participants in these conditions rated up to three different occasions of the false narrative in order from most to least vivid.

Each measure of false memory formation is subject to different limitations and sources of error. Some participants tended to be less verbally descriptive about their childhood narratives over time (possibly following an implicit norm of avoiding redundancy). That is, a participant's self-reports about the vividness of their (false) memories could remain somewhat consistent or increase over time, but researcher coding could suggest that this participant, for example, formed partial false memories in the first interview and accepted false memories in the second and third interview. Thus, examining all three of the relevant measures and interpreting their results taken together leads to the most trustworthy conclusions.

We start with a subsection reporting results corresponding to Hypothesis 1, which refers to false memory rates of the Standard group, as coded by the researcher, being similar to the literature benchmark rates (Scoboria et al., 2017). Subsequently, we present descriptive results of the data. For the self-report data and researcher coding, we present inferential analyses corresponding to: Hypothesis 2, which refers to the false memories being more difficult to implant under the Repeated and Gradual groups' conditions compared to the Standard group's conditions; and Hypothesis 3, which involved comparing the Repeated and Gradual groups, predicting that false memory implantation would be more successful in the latter.

Comparison to Past Implantation Studies

To address Hypothesis 1, we examined the Standard condition in the present experiment which is equivalent to the implantation approach of all studies reported in Scoboria et al. (2017). For this comparison, we counted the number of participants who provided a report in any interview session that met the criteria of partial, full, or robust false memory. In the Standard condition ($n = 39$) of the current experiment, 25% (10) of participants formed false memories and 77% accepted the false narrative as true, as assessed

by the researcher rating. False recollection rates were lower than the literature benchmark of 46% for false memory ($N = 423$; Scoboria et al., 2017), $\chi^2(1, N = 462) = 5.92$, $\phi = 0.12$, $p = .01$. There was a small, nonsignificant difference between the literature benchmark of 69% and the current experiment for false belief rates ($N = 423$; Scoboria et al., 2017), $\chi^2(1, N = 462) = 1.11$, $\phi = 0.04$, $p = .30$.

Researcher Ratings

Due to damaged audio files, interviews for 2 participants (one in the Standard and one in the Gradual condition) could not be coded. Thus, the group sizes available for coding were as follows: Standard $n = 39$; Repeated $n = 41$; and Gradual $n = 38$.

Participants in the Single condition ($n = 39$) each provided three measure of belief and three of recollection (one in each of the three Interviews). Participants in the Repeated condition ($n = 41$) each provided nine measures of belief and nine of recollection (three incidents in each of three interviews). Participants in the Gradual condition ($n = 41$) each provided seven measures of belief and seven of recollection (one incident in Interview 1 and three incidents in Interviews 2 and 3).

Descriptive Analysis

In Table C2, we show descriptive results concerning the researcher ratings for each participant measurement. The table displays the count for the cases pertaining to each category and, in parentheses, the percentages from the total amount of cases for each implantation category. Figure C1 shows the development of false memory implantation over time (interview sessions 1, 2, and 3). Here, we can see the rating attributed by the researcher to each of the three possible occasions of the false narrative across the three interview sessions. These results show that a non-trivial number of false memories fall into the “Accepted False Memory” category by interview session 3 (Standard condition: 38%; Repeated condition: 22%; and Gradual condition: 26%). A smaller number of false memories

fall into the “Partial False Memory”, “Full False Memory” and “Robust False Memory” categories. Additionally, 25% of participants in the Repeated group and 34% of participants in the Gradual group described two or more occurrences of the false narrative that under the researcher rating were categorized between the “Accepted False Memory” category and the “Robust False Memory”.

In Table C3, we can see the detailed report for each participant who described two or more occurrences of the false events that the researcher classified as Accepted, Partial, Full or Robust false memory. There are different “evolution” patterns of false memories. Table C3 shows that a few participants’ statements suggested that their false memories were decreasing in vividness over time. For instance, the researcher assessed that in their first interview, participant 2 in the Repeated condition offered verbal information that matched a Robust false memory classification. However, on participant 2’s second and third interview, the researcher considered the information provided fitting with the Accepted false memory category, which is inferior to Robust false memory classification in terms of false memory richness. It is not our objective to thoroughly attribute a justification for the manner participants chose to communicate their memories, but it is possible that participants avoided redundancy in their statements. For instance, participant 2 says in their third interview “I remember it. I think it is very blurry. Like I said last week. I can still remember mum talking to me about the lost elephant.”

Inferential Analysis

Analytic Approach. For the Repeated and Gradual conditions, the researcher had up to three occurrences of the false narrative to rate. Researchers also rated the quality of these occurrences (first most vivid, second most vivid and third most vivid). Participants narrated their memories for the different occurrences of the false narrative ordering them from the one they remembered the most to the one they remembered the least.

To assess false memory formation elicited by the implantation approaches (Standard, Repeated, and Gradual) we used cumulative link mixed effects models. For this we used the ordinal package (Christensen, 2019) for R. For this model, we analyzed the six false memories categories displayed in Table A2. We applied the same rationale to the researcher coding as we did for participants' self-rating. Hence, the model for Hypothesis 2 included fixed effects for condition (Standard, Repeated, and Gradual) and interview sessions (1, 2, and 3). To test Hypothesis 2, we compared all three groups via the first most vivid occurrence from participants in the Repeated and Gradual group with the only occurrence participants reported in the Standard group. The model also included numeric factors (i.e., 0: interview 1; 1: interview 2; and 2: interview 3) and random intercepts for participants.

To test Hypothesis 3, we included in the model fixed effects for the Repeated and Gradual conditions to all sessions (1, 2, and 3) and occurrences of the false narrative (most vivid, second most vivid, and third most vivid). With the exception of the first interview in the Gradual group, both the Repeated and Gradual group allowed participants to report up to three occurrences of the false narrative. For this reason, we included fixed effects to the model we used to assess Hypothesis 3 and compare both implantation methods. The fixed effects for interview condition and occurrences used treatment contrasts (dummy coding), with the first listed level for each factor as the reference group. Furthermore, this model included numeric factors (i.e., 0: interview 1; 1: interview 2; and 2: interview 3) and random intercepts for participants.

Data Transformation. Recall that participants had up to three occurrences to rate; consequently, the research also had up to three occurrences of the false narrative to rate. Whenever a participant did not describe a false occurrence, we treated this particular occurrence as “no memory” (see Table A2). This was always the case for the second and third most remembered occurrence for the Standard group, considering that we did not intend

to implant false memories for repeated events in this condition. It was also the case, for the second and third most vivid occurrence in the first interview session of the Gradual condition. Other than this, every time a participant recalled, for instance, a first and second occurrence, but not a third, the third occurrence in this example was treated as missing value and therefore “no memory”.

Model Selection. Similar to our model selection for the analysis of the data from the self-report rating, we took a hierarchical approach also fitting two models for Hypothesis 1 and Hypothesis 2 and a three-way interaction model for Hypothesis 3. The models consisted of one with main effects for the fixed factors and another with two-way interactions for Hypotheses 2 and 3 and a third one with three-way interactions solely for Hypothesis 3.

Assessing *Hypothesis 2*, the second model that included two-way interactions fit the data better than the first model, $\chi^2(2) = 7.25, p = .02$.

Assessing *Hypothesis 3*, the second model, including two-way interactions, fit the data better than the first model, $\chi^2(5) = 12.50, p = .02$. The third model did not fit the data better than the second, $\chi^2(2) = 0.53, p = .76$. Thus, we retained the model that included the two-way interactions. We report results for the retained model here, but information about all other models used in this study is available in supplementary material (see https://osf.io/4fzht/?view_only=cf0035032a124786b7ccce67ec60e43c).

Possible Differences among Interviewers. We found some evidence for differences in the rates of false memory implantation among the eight interviewers who worked in the current project. We compared the retained model comparing the Repeated and Gradual conditions (Hypothesis 3) to a model that added random intercepts for interviewers. The model in which there were random intercepts for interviewers outperformed the retained model, $\chi^2(1) = 9.18, p = .002$. Additionally, in the model that compared all three conditions on the most vivid occurrence (Hypothesis 2), a model adding random intercepts for interviewers did not outperform the retained model, $\chi^2(1) = -2.46, p = .99$. These results should be interpreted with caution, since there were an uneven number of interviews conducted by each of the eight interviewers. Moreover, cumulative link mixed models with more than one random effect have numerous technical limitations. For that reason, we decided to retain the models stated above.

Modeling Results.

Hypothesis 2. Hypothesis 2 conveyed that false memories for repeated events would be more difficult to implant than false memories for single events. Hence, in this analysis we compared results from the Standard group with results from the first occurrence of the Repeated and the Gradual groups. In the model presented in Table 3, the coefficients for the Repeated and Gradual groups respectively represent the difference (or lack thereof) in false memory formation between that group and the Standard condition, in the first interview session. The interview session coefficient represents the change in false memory formation over the three interview sessions in the Standard group. The interaction terms represent the difference in false memory formation over time between the Standard group and the Repeated and Gradual groups respectively.

Consistent with participants self-rating results, this model showed that false memory formation in the Repeated and Gradual conditions were not significantly lower than in the

Standard condition. Additionally, as displayed in Table 3, false memory formation appeared to increase significantly over time in the Repeated group compared to the Standard group.

Table 3

Cumulative Link Mixed Effects Model Results Comparing Participants' False Memories in the Standard, Repeated, and Gradual Groups

Fixed effects	Unstandardized coefficient (b)	SE	z	p-value
Repeated condition	-1.28 [-2.85, 0.29]	0.80	-1.58	.11
Gradual condition	-0.02 [-1.63, 1.59]	0.82	-0.03	.97
Interview sessions	-0.03 [-0.48, 0.42]	0.23	-0.12	.89
Repeated condition x interview sessions	0.88 [0.23, 1.53]	0.33	2.60	<.01
Gradual condition x interview sessions	0.29 [-0.36, 0.94]	0.33	0.86	.38
Random effects	SD			
Participants	2.90			

Hypothesis 3. In Hypothesis 3 we were interested whether the approach we employed in the Gradual condition would elicit false memories in more participants compared to the method we used in the Repeated condition. In the model presented in Table 4, the coefficient for the Gradual condition represents the difference in false memory formation between the Gradual and Repeated conditions, for the most vivid occurrence and in the first interview session. The interview session coefficient represents the change in false memory formation over the three interview sessions in the Repeated group. The interaction term with interviews sessions represents the difference in false memory formation over time between the Repeated group and Gradual group. The coefficients for the second and third most vivid occurrence represent the difference in false memory formation between that occurrence and the most vivid occurrence, in the Repeated condition. The interaction terms with the second and third occurrence represent the difference in false memory formation

between the Repeated group and Gradual group for those occurrences, compared to the most vivid occurrence.

Table 4 shows that participants in the Gradual condition are slightly more likely to form at least one false memory in the first interview session. However, the tendency for participant's false memories to increase over time is lower in the Gradual condition compared to the Repeated condition.

Table 4

Cumulative Link Mixed Effects Model Results Comparing Participants' False Memories in the Repeated and Gradual Condition

Fixed effects	Unstandardized coefficient (b)	SE	z	p-value
Gradual condition	1.03 [0.05, 2.01]	0.50	2.07	.03
Interview sessions	0.81 [0.81, 0.81]	<.01	354.13	<.0001
Occurrence 2	-1.35 [-1.35, -1.35]	<.01	-375.33	<.0001
Occurrence 3	-0.89 [-0.89, -0.89]	<.01	-293.39	<.0001
Gradual condition x Interview sessions	-0.54 [-0.91, -0.17]	0.19	-2.79	.005
Gradual condition x Occurrence 2	0.66 [0.01, 1.31]	0.33	2.00	.44
Gradual condition x Occurrence 3	0.11 [-0.54, 0.76]	0.33	0.34	.72
Interview sessions x Occurrence 2	-0.68 [-0.68, -0.68]	<.01	-199.41	<.0001
Interview sessions x Occurrence 3	-0.83 [-0.83, -0.83]	<.01	-274.44	<.0001
Random effects	SD			
Participants	2.48			

Participants Self-Report Ratings

Descriptive Analysis

The average of participants self-report across all three conditions were higher for belief compared to recollection. False recollection and false belief ratings for the second most and third most vivid memories were lower compared to the most vivid memory. If no one formed

false memories or beliefs for repeated events, the second and third most vivid occurrences would have means of 1.00 for recollection and belief, with no variance. However, one can clearly see that false recollection and false belief self-reporting in the Repeated and Gradual condition are not constrained to the negative endpoint of the scale for the second and third most vivid occurrences. Thus, participants in those conditions sometimes reported that they remembered or believed that the suggested false event occurred more than once.

Figure 2 shows false recollection and false belief ratings tend to increase over time in the Gradual and Repeated conditions. Note that for both the false recollection and false belief measures, the mean values at all time points and in all conditions are fairly low on the respective scales, never rising above the midpoint.

Figure 2

Mean Self-Reported Recollection and Belief for the False Narrative

Note: Error bars represent standard errors.

Inferential Analysis

Analytic Approach. We used linear mixed-effects modeling to assess the success of the implantation approaches (Standard, Repeated, and Gradual). We used the lme4 package (Bates et al, 2015) for R. This package was complemented with the lmerTest package (Kuznetsova, Brockhoff, & Christensen, 2017) to obtain Satterthwaite approximated degrees of freedom. Our models used restricted maximum likelihood (REML) estimation. Each participant provided up to 9 measures for belief and 9 for recollection (described in more detail below), providing up to $N = 1080$ valid observations for each measure. The model for Hypothesis 2 included fixed effects for condition (Standard, Repeated, and Gradual) and

Interview Sessions (1, 2, and 3). Even though participants in the Standard group only reported one occurrence of the false narrative, such fixed effects allowed us to compare all three groups (Hypothesis 2) for the first most vivid occurrence of the Repeated and Gradual group, and the only occurrence of the Standard group.

For Hypothesis 3 the model included fixed effects for condition (Repeated and Gradual), interview session (1, 2 and 3) and occurrences (most vivid, second most vivid, and third most vivid). We added the three occurrences of the false narrative only to test Hypothesis 3, because this hypothesis compares the Repeated and Gradual groups. With the exception of the first interview session for the Gradual group, participants in the Repeated and Gradual groups had the possibility of narrating up to 3 occurrences of the false narrative. The fixed effect for the interview sessions used treatment contrasts (dummy coding) and numeric factors (i.e., 0: interview 1; 1: interview 2; and 2: interview 3). The fixed effects for occurrences also used treatment contrasts (dummy coding), with the first listed level for each factor as the reference group. The models included random intercepts for participants³.

Model Selection. We took a hierarchical approach to model selection. In the first step, we fit a model including only main effects for each of the fixed factors. In the second step, we added the two-way interactions. We compared each model to the previous step using a likelihood ratio test. These comparisons required refitting the models using maximum likelihood instead of REML, but all reported results use the REML fittings.

Assessing *Hypothesis 2*, for the recollection measure, the second model did not offer a significant improvement compared to the first model, $\chi^2(2) = 2.21, p = .33$. The same occurred for the belief measure, the second model (including two-way interactions) did not fit

³ This is a different analysis than what we had proposed in our first pre-registration. We realized before the end of data collection that our original analytic strategy (i.e., mixed ANOVA) would not be as informative as a multilevel modeling approach. We therefore revised our analysis plans for both the self-report data and researcher coding. We registered these changes on OSF prior to data collection: https://osf.io/4fzht/?view_only=cf0035032a124786b7ccce67ec60e43c.

the data significantly better than the first model, $\chi^2 (2) = 2.38, p = .30$. Thus, for both self-report measures (recollection and belief), we retained the model that main effects only. We report results for those retained models here, but information about the other models is available in supplementary material (see https://osf.io/4fzht/?view_only=cf0035032a124786b7ccce67ec60e43c).

Assessing *Hypothesis 3*, for the recollection measure, neither the second, $\chi^2 (5) = 3.07, p = .68$, nor third model (including three-way interactions), $\chi^2 (2) = 2.81, p = .24$, fit the data better. For the belief measure, both the second and third model also did not fit the data significantly better. For this reason, we report in this section results concerning the first model, for both recollection and belief measures.

Modeling Results for Participants Self-Report Ratings.

Hypothesis 2. We aimed to assess if false memories for repeated events were more difficult to implant than false memories for single events. Here, we compared participants' self-rated recollection and belief ratings in the Standard group to the Repeated and Gradual groups, specifically for participants most vividly recalled event (excluding the second and third most vivid events). The results are presented in Table 5 and Table 6. In each of these models, the coefficients for the Repeated and Gradual conditions respectively represent a comparison of that condition to the Standard condition. The coefficient for interview sessions represents the linear change in the dependent variable over the three interview sessions.

Against our predictions, neither the Repeated nor Gradual condition demonstrated significantly lower ratings of recollection or belief compared to the standard condition. Additionally, in all three groups, participants tended to rate their recollection for the false narrative higher on their second and third interview session than they did in their first interview session. There was a similar but nonsignificant tendency for belief ratings to increase over the interview sessions.

Table 5

Linear Mixed Effects Model Results for False Recollection Ratings

Fixed effects	Unstandardized coefficient (<i>b</i>)	<i>SE</i>	<i>t</i>	<i>df</i>	<i>p</i> -value
Intercept (Standard)	1.53 [1.08, 1.98]	0.23	6.55	137.91	<.0001
Repeated condition	0.21 [-0.40, 0.82]	0.31	0.68	116.99	.49
Gradual condition	0.21 [-0.42, 0.84]	0.32	0.68	116.99	.49
Interview sessions	0.23 [0.11, 0.35]	0.06	3.56	239.00	<.001
Random effects	<i>SD</i>				
Participants	2.84				

Note: Coefficients are displayed with 95% CIs.

Table 6*Linear Mixed Effect Model Results for False Belief*

Fixed effects	Unstandardized coefficient (b)	SE	t	df	p-value
Intercept (Standard)	3.36 [2.73, 3.99]	0.32	10.39	136.37	<.0001
Repeated condition	0.25 [-0.61, 1.11]	0.44	0.57	117.	.56
Gradual condition	0.36 [-0.50, 1.22]	0.44	0.82	117.	.40
Interview sessions	0.16 [0.00, 0.32]	0.08	1.87	239.	.06
Random effects	SD				
Participants	1.37				

Note: Coefficients are displayed with 95% CIs.

Hypothesis 3. We aimed to assess if false memory implantation for repeated events would be facilitated by the method we employed in the Gradual group. Hence, this model compared participants' self-rating for each occurrence of the false narrative (up to three) in the Repeated and Gradual groups at all three times. In both models, the coefficient for the Gradual condition represents a comparison between that condition and the Repeated condition. The coefficient for interview sessions represents the linear change in the dependent variable over the three interview sessions. The coefficients for the second and third most vivid occurrences respectively represent comparisons of that occurrence with the most vivid occurrence.

Table 7 and Table 8 show that, against our prediction, participants in the Gradual group did not tend to provide higher recollection or belief ratings compared to the Repeated group. Additionally, participants' ratings of both recollection and belief tended to increase significantly over the three interview sessions. Unsurprisingly, the second and third most vivid occurrences received significantly lower recollection and belief ratings compared to the first.

Table 7

Linear Mixed Effect Model Results for False Recollection Across Repeated and Gradual Conditions

Fixed effects	Unstandardized coefficient (b)	SE	t	df	p-value
Intercept (Repeated)	1.72 [1.34, 2.10]	0.19	8.92	97.01	<.0001
Gradual condition	0.08 [-0.42, 0.60]	0.25	0.33	77.44	.73
Interview sessions	0.22 [0.13, 0.32]	0.04	4.57	550.71	<.0001
Second most vivid occurrence	-0.45 [-0.64, -0.28]	0.09	-4.94	550.71	<.0001
Third most vivid occurrence	-0.58 [-0.77, -0.41]	0.09	-6.36	550.71	<.0001
Random effects	SD				
Participants	1.09				

Table 8

Linear Mixed Effect Model Results for False Belief Across Repeated and Gradual Conditions

Fixed effects	Unstandardized coefficient (b)	SE	t	df	p-value
Intercept (Repeated)	3.60 [3.05, 4.15]	0.28	12.817	98.38	<.0001
Gradual condition	0.09 [-0.65, 0.83]	0.37	0.24	78.06	.80
Interview sessions	0.19 [-0.05, 0.34]	0.07	2.61	551.31	<.01
Second most vivid occurrence	-1.47 [-1.75, -1.21]	0.13	-10.83	551.31	<.0001
Third most vivid occurrence	-1.87 [-2.15, -1.61]	0.13	-13.75	551.31	<.0001
Random effects	SD				
Participants	1.59				

Discussion

Since false memory implantation studies exclusively have focused on single events, scholars have criticized such studies for potentially not applying to cases in which people allege multiple repeated instances of an offense (Blizard & Shaw, 2019; Brewin & Andrews, 2010). However, the present experiment demonstrates that it is indeed possible to form false

autobiographical memories for repeated events in lab conditions. Moreover, although we had expected the rate of false memories implantation to be lower in the Repeated and Gradual conditions, surprisingly, participants in the Repeated and Gradual groups formed false memories approximately as often and as vividly as participants in the Standard condition.

Many of our everyday experiences are repeated routine events. Without details that make an occurrence of a repeated event stand out, all occurrences tend to collapse together into one gist or schema (Rubínová, Blank, Ost, & Fitzgerald, 2020). For this reason, people may have an intuitive meta-memorial understanding that events they should have a schematic memory for are events they have experienced repeatedly. In the absence of such a schema, one might doubt that a suggested repeated event in fact occurred. Thus, we expected participants to be more skeptical of the suggestion that they experienced a false event repeatedly. Such rationale led us to opt for a highly plausible event that somewhat contrasts with some of the previous literature in which the likelihood of the false event taking place could be considered slimmer than losing an elephant toy as a child (e.g., hot air balloon ride; see Wade et al., 2002). The prediction that false memories for repeated events would be more difficult to implant compared to false memories for single events was not borne out, and instead participants in the Repeated and Gradual conditions seemed no more skeptical than those in the Standard condition. Perhaps these results were due to people's intuitive understanding of how difficult it is to retrieve accurate details of repeated experiences. Because people may be intuitively aware of the poor quality of their memories for repeated events (e.g., the inability to differentiate specific episodes and the inability to retrieve a single episode), their suspicion towards the veracity of the false narrative may have been mitigated. Another possibility has to do with the source of script memory. Scripts can be learned vicariously (Slackman & Nelson, 1984). That is, personal experience is not necessary to acquire a script for an event. Given that scripts are not tightly linked to specific episodes, it

may be easy to lead a person to believe in a script they acquired through a source other than their direct experience.

As this is the first study investigating false memory implantation for repeated autobiographical events, we believe our findings should be generalized with caution beyond the point of proof of concept that false memories for repeated events can be implanted. At this point, we cannot speak to the particular moderators that are likely to exist for false memory implantation for repeated events. Different types of false memories are not necessarily correlated (Calado et al., 2018; Falzarano & Siedlecki, 2019; Ost et al., 2013, Zhu et al., 2013). Despite being elicited via the same method (i.e., lost-in-the-mall-paradigm), it could be the case that false memories for repeated events and false memories for single events are elicited due to distinct mechanisms. Hence, understanding false memory moderators for single and repeated events may be a way to determine to what extent studies on false memory implantation for single events might be generalized to cases on possible false memories for repeated events.

Limitations and Future Research

The false memory rate in our study for the Standard group was not as high compared to false memory implantation rates provided in previous studies (Scoboria et al, 2017), however our results are not outside the typical range (see Table A1). Differences between the implanted events in previous studies (e.g., positive versus negative events) and the way implanted false memories are scored (see Shaw & Porter, 2015; Wade, Garry, & Pezdek, 2018) may play an important role determining the rate of false memory formation. Importantly, to our knowledge, the current experiment is one of the few experiments that used different ways to score false memories (i.e., self-reports and researcher ratings; see Otgaar et al., 2013). Arguably, having two different ways to measure false memories reports, instead of only one, advocates on the reliability of our results.

Despite efforts in manufacturing false events that share possible negative features with sexual abuse, a limitation shared by false memory implantation studies concerns the external validity of such false events. Different from lab conditions, sexual abuse cases concern highly distressing events that have personal relevance for victims (for contextualization on the complexity and effects of sexual abuse for victims, see: Marx & Sloan, 2002; Murrey et al., 2015; Schönbucher et al., 2012; Wolfe et al., 1994). There was no clear motivation for participants in the current experiment to try to remember the episode we were attempting to implant—a limitation shared by previous studies on false memory implantation (see Table A1). Sometimes, alleged victims who have had false memories of abuse, eventually, realize that their abusive memories were not authentic (Maran, 2010). When explaining their experience, they occasionally state they were motivated to form such false memories because they wanted to resolve personal issues that could be explained by, for example, having experienced abuse (Lindsay & Read, 1994; Maran, 2010). However, “motivation to recall” is a challenging feature for scientists to ethically include in false memory laboratory studies.

Furthermore, one might argue that by choosing a highly plausible event to implant, we have made the false memory implantation less likely to happen in our study. That is, participants could have potentially less motivation to recall a plausible event compared to an implausible one with more exciting content, such as a hot air balloon ride. We advocate that motivation towards specific events is difficult to generalize. In this case, some people could find a given event fascinating and hence make an effort to recall it, however others could simply not find such motivation for the same event. Given the possible lack of consistency in what could be considered an exciting event that would likely engage participants’ motivation to recall it, we argue that such nuances fall within the scope of individual differences which we did not investigate in the current experiment. As previously stated, when experimenting

with the implantation of false repeated events for the first time, we primed to assure that we simply had a highly plausible event. We believed that a highly plausible event could facilitate implantation since it would be generally relatable and at the same time, it would likely disregard particular individual differences.

Another possible limitation concerns the fact that our research assistants who interviewed participants were familiar with the design and hypotheses of our study. In such a logistically complex study, interviewers must at least be familiar with the design and procedures. Even if we had attempted to fully blind them, it would have been obvious that all participants were being told they had lost an elephant cuddly toy during their childhood, being easy to infer the purpose of that procedure. However, if the lack of blinding affected our results, one might expect that our results would be more in line with our hypotheses. The fact that we found opposite results speaks against the severity of this threat to validity. Additionally, researchers who rated the memory reports were blind to the hypotheses. Taken together, it is likely that our results were not severely affected by interviewers' prior knowledge of the hypotheses of the current experiment.

Finally, our approach of letting participants come up with the occurrences of the general false experience we attempted to implant was necessary at this point for our method to be comparable with the classic implantation method. We believe, however, that future research on implantation of false memories for repeated events should move from our methodology something into more specific to implant false memories for repeated events. For instance, defining the exact occurrences of the same experience to be implanted and guiding participants through them would likely increase false memories rates for repeated events.

Conclusion

The present experiment offers the first demonstration that, under some circumstances, false memories for repeated autobiographical events can be implanted, in much the same way

that false memories for single events can. Furthermore, if our findings can be generalized to repeated victimization, false memories for repeated events could have a powerful impact on people's lives—especially when such false memories answer relevant questions one has about oneself (e.g., why one is experiencing depression or anxiety). When entering the courtroom, memory distortions may come at high costs, often rendering years of emotional distress to the parties involved and ultimately the imprisonment of an innocent person. While our experiment cannot provide an estimate of the extent to which false memories for repeated events play a role in the legal system, their potential consequences are great, and they are a psychological phenomenon worthy of future attention in research.

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Appendix A

Table A1

Implantation Method Studies Focused on Single Events in Adult Participants

Authors	False event	Type of stimuli	Guided imagery	Sample	Rates of any level of false memory formation	Additional Information
Loftus and Pickrell (1995)	To be lost in a shopping mall or big department store	Participants read a description booklet	No	24 adults	20%	False narrative adapted to be coherent with participants' life
Hyman et al. (1995) Experiment 1	Birthday with pizza and a clown visit/ overnight at the hospital	Researchers narrated the event	No	20 adults	20%	Selected 1 of the 2 events accordingly to participants' life; emotion valence between subjects
Hyman et al. (1995) Experiment 2	To spill punch at wedding/ fire sprinkler being activated at a shop/ to release the hand break of a car causing small crash	Researchers narrated the event	No	51 adults	26%	Selected 1 of the 3 events accordingly to participants' life; participants could add their own emotional interpretation of the false events
Hyman and Pentland (1996)	To spill punch at wedding	Researchers narrated the event	Yes (1 condition)	65 adults	12% without guided imagery 36% with guided imagery	Guided imagery between subjects
Pezdek et al. (1997) Experiment 1	To do something embarrassing at a religious ceremony (Catholic or Jewish)	Participants read a description booklet	No	51 high school students (Catholic and Jewish)	6% implausible 22% plausible	Plausibility between subjects
Pezdek et al. (1997) Experiment 2	To be lost in a shopping mall/ to received rectal enema	Researchers narrated the event	No	20 adolescents	0% lower plausibility 15% high plausibility	Plausibility and script-knowledge between subjects
Hyman and Billings (1998)	To spill punch at wedding	Researchers narrated the event	Yes	66 adults	27%	Use of individual differences measurements
Porter et al. (1999)	To undergo medical procedure/to get lost/ to be harmed by another child/ to be attacked by an animal/	Researchers narrated the event	Yes	77 adults	56%	Selected 1 of the 6 events accordingly to participants' life; comparison of real, implanted and fabricated memories

		indoor accident/ outdoor accident				
Heaps and Nash (2001)	Life Events Inventory (LEI)	Researchers narrated the event	Yes	63 adults	37%	Selected 1 of the 42 LEI events, accordingly to participants' life
Wade et al. (2002)	Hot air balloon ride	Participants viewed doctored photographs	Yes	20 adults	50%	Interviews followed a modified version of the Step-Wise procedure
Lindsay et al. (2004)	To put Slime (gelatinous toy) on the teachers' desk in Grade 1 or 2	Researchers narrated the event, presenting or not (real) photographs	Yes	45 adults	46% without photograph 78% with photograph	Presentation of a real school photograph between subjects
Garry and Wade (2005)	Hot air balloon ride	Participants read a description booklet containing or not (doctored) photographs	Yes	44 adults	50% with doctored photograph 82% with verbal narrative	Doctored photograph between subjects
Ost et al. (2005)	To go to the hospital/ to get lost/ family holiday/ to attend a wedding/ to win a contest/ death of a friend or relative/ accident with friend or family	Researchers narrated the event	No	31 adults	23%	Selected 1 of the 8 events accordingly to participants' life
French et al. (2006)	Hot air balloon ride	Participants accessed personalized events on a password-protected web page through photographs or description	No	58 adults	24%	Investigated the influence of discussing false events with family members over false memory rates; for the false narrative doctored photographs were used
Desjardins and Scoboria (2007)	To put Slime (gelatinous toy) on the teachers' desk in Grade 1 or 2 with the addition or not of self-relevant details and/or specific details	Participants read a description booklet	Yes	44 adults	68% with self-relevant details 36% without self-relevant details	Used the Autobiographical Belief and Memory Questionnaire (ABMQ); details: Self-relevant and specific, self-relevant only, specific only, and no self-relevant or

						specific details were conditions between subjects
Qin et al. (2008) Experiment 1	Birthday party at McDonalds/ to get lost/ to receive rectal enema	Participants read a text description	Yes (1 condition)	119 adults	Varies between according to condition: 36–16%	Selected 1 of the 2 events accordingly to participants' life; used warning about false memory formation between subject
Strange et al. (2008)	Hot air balloon ride	Researchers narrated the event	No	105 adults	38% 2 years old 19% 10 years old	Age difference in which the false event occurred between subjects (2 years old vs. 10 years old)
Wade et al. (2010)	Hot air balloon ride	Participants read a description booklet and viewed a photograph booklet	Yes	53 adults	67% narrative first 41% doctored photograph first	Order of presenting doctored photograph (first, or last) between subjects
Short and Bodner (2011)	Researchers selected to each participant plausible events that had happened to other participants in the study	Researchers narrated the event	Yes	34 adults	41%	Used the Judgment of Memory Characteristics Questionnaire (JMCQ) and the Cognitive interview; used actual events, fabricated events and suggested events
Hessen-Kayfitz and Scoboria (2012)	Hot air balloon ride	Participants viewed booklet of doctored photographs with brief description	Yes	82 adults	Varies between according to condition: 47–24%	Used the Autobiographical Belief and Memory Questionnaire (ABMQ); presence of salient familiar details and absence of salient familiar details between subjects
Otgaar et al. (2013) Experiment 1	Hot air balloon ride	Researchers narrated the event	Yes	89 adults	36%	Used the Memory Characteristic Questionnaire (MCQ) and Memory or Belief Form (MBF); also investigated non-believed memories

Shaw and Porter (2015)	To commit assault; to commit assault with a weapon; to commit theft; self-injury; to be attacked by a dog; to lose a lot of money	Researchers narrated the event	Yes	60 adults	70% criminal false memories 77% non-criminal false memories*	Rates were taken explicitly from self-reports. Criminal and non-criminal false memories between subjects
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*False memory has been operationalized differently across published studies.

Furthermore, due to the unusually high false memory rates in this study, Wade and colleagues (2018) recoded the raw data and found rates between 26% to 30%.

Table A2

Scoring Definition for False Memory Categories

Category	Acceptance level	Elaboration level	Imagery level
Robust False Memory	High	Moderate or higher	Moderate or higher
Full False Memory	Moderate	Moderate or higher	Moderate or higher
Partial False Memory	Moderate	Low or higher	Low or higher
Accepted False Memory	Moderate	-	-
No False Memory	Low	-	-
Rejected False Memory	None	-	-

Appendix B

Table B1

Nationalities of Participants

Country	N	%
Germany	28	23.3
Netherlands	22	18.3
Belgium	6	5
Multiple Nationalities	5	4.2
United States of America	5	4.2
Greece	4	3.3
Indonesia	4	3.3
Spain	4	3.3
Bulgaria	3	2.5
Finland	3	2.5
Ireland	3	2.5

Italy	3	2.5
Portugal	3	2.5
Brazil	2	1.7
Cyprus	2	1.7
France	2	1.7
Hungary	2	1.7
India	2	1.7
Mexico	2	1.7
Poland	2	1.7
United Kingdom	2	1.7
Canada	1	0.8
China	1	0.8
Ethiopia	1	0.8
Iran	1	0.8
Luxemburg	1	0.8
Norway	1	0.8
Peru	1	0.8
Sweden	1	0.8
Taiwan	1	0.8
Turkey	1	0.8
Zimbabwe	1	0.8

Table B2
Participants' Gender.

Gender		
	Frequency	%
Female	94	78.3
Male	26	21.7

Table B3
Participants' Age Means and Median.

Age	
<i>N</i>	120
<i>M</i>	22.28
<i>Mdn</i>	21.00
<i>SD</i>	3.495
Kurtosis	0.534
Minimum	18
Maximum	32

Table B4
Frequency Distribution of Participants' Ages

Age		
<i>N</i>	Frequency	%
18	4	3.3
19	24	20.0
20	24	20.0
21	13	10.8
22	9	7.5
23	8	6.7
24	11	9.2
25	8	6.7
26	5	4.2
27	2	1.7
28	2	1.7
29	1	0.8
30	4	3.3
31	3	2.5
32	2	1.7

Table B5
Participants' Marital Status

Marital Status		
	Frequency	%
Single	117	97.5
Married	2	1.7
Divorced	1	0.8

Table B6
Participant's Educational Status

Educational Status		
	Frequency	%
Missing	1	0.8
Not specified	1	0.8
Bachelors	76	63.3
Masters	39	32.5
PhD	3	2.5

Belief and Recollection after Debriefing

Note: Table C1 contains the frequency and percentage of participants' self-ratings for the false narrative after learning that they did not experience it. The rating was the same as the one used for the stories during the interview sessions, in which 1 stood for "this did not happen to me" or "I do not recall this event" and 8 "I am completely confident that this happened to me" or "I remember this event completely."

Counts of Memory Reports per Category of False Memory Formation across the Three

Standard Condition n = 39							
Up to 3 measurements per participant (n = 117)							
Interview	Rejected False Memory	No False Memory	Accepted False Memory	Partial False Memory	Full False Memory	Robust False Memory	Total
1	4 (10.2)	12 (30.7)	18 (46.1)	1 (2.5)	2 (5.1)	2 (5.1)	39
2	5 (12.8)	8 (20.5)	16 (41.0)	6 (15.3)	1 (2.5)	3 (7.6)	39
3	6 (15.3)	11 (28.2)	14 (35.8)	4 (10.2)	2 (5.1)	2 (5.1)	39
Repeated Condition n = 41							
Up to 9 measurements per participant (n = 369)							

Interview	Rejected False Memory	No False Memory	Accepted False Memory	Partial False Memory	Full False Memory	Robust False Memory	Total
1	13 (10.5)	81 (65.8)	24 (19.5)	3 (2.4)	1 (0.8)	1 (0.8)	123
2	11 (8.9)	82 (66.6)	17 (13.8)	6 (4.8)	6 (4.8)	1 (0.8)	123
3	9 (7.3)	72 (58.5)	28 (22.7)	8 (6.5)	3 (2.4)	3 (2.4)	123

Gradual Condition n = 38

Up to 7 measurements per participant (n = 266)

Interview	Rejected False Memory	No False Memory	Accepted False Memory	Partial False Memory	Full False Memory	Robust False Memory	Total
1	9 (25)	0	20 (55.5)	4 (11.1)	2 (5.5)	1 (2.7)	36
2	15 (13.1)	45 (39.47)	34 (29.8)	7 (6.1)	12 (10.1)	1 (0.8)	114
3	11 (9.6)	58 (50.8)	30 (26.3)	4 (3.5)	10 (8.7)	1 (0.8)	114

Note: Values are frequency counts with percentages in parentheses. The cases displayed on the table do not correspond to the number of participants but rather to all measurements from each participant.

Table C3

Participants who Described Two or More Occurrences of the False Narrative Classified by the Researcher as Accepted, Partial, Full, or Robust False Memory

Repeated Condition n = 10				
Participant	Occurrence	Interview Session 1	Interview Session 2	Interview Session 3
1	1	-	-	Accepted
	2	-	-	Accepted
	3	-	-	Accepted
2	1	Robust	Accepted	Accepted
	2	-	Accepted	-
	3	-	-	-
3	1	Accepted	Full	Accepted
	2	Accepted	Partial	Full
	3	Accepted	Full	Accepted
4	1	Accepted	Accepted	Accepted
	2	-	-	Accepted
	3	-	-	-
5	1	Accepted	Accepted	Accepted
	2	Accepted	Accepted	Accepted
	3	Accepted	Accepted	Accepted

6	1	Accepted	Accepted	Accepted
	2	Accepted	Accepted	Accepted
	3	Accepted	Accepted	Accepted
7	1	Partial	Partial	Partial
	2	Partial	Partial	Partial
	3	Partial	Partial	Partial
8	1	Accepted	Accepted	Accepted
	2	Accepted	Partial	Partial
	3	-	-	-
9	1	Accepted	-	-
	2	Accepted	-	-
	3	Accepted	-	-
10	1	Accepted	Full	Accepted
	2	-	-	Full
	3	-	-	-

Gradual Condition n = 14

Participant	Occurrence	Interview Session 1	Interview Session 2	Interview Session 3
1	1	Accepted	Full	Partial
	2	-	Accepted	Accepted
	3	-	Accepted	Accepted
2	1	Accepted	Full	Accepted
	2	-	Accepted	Accepted
	3	-	-	Accepted
3	1	Accepted	Full	Full
	2	-	Full	Full
	3	-	Full	Full
4	1	Accepted	Accepted	Accepted
	2	-	Accepted	Accepted
	3	-	Accepted	Accepted
5	1	Accepted	Accepted	Accepted
	2	-	Accepted	Accepted
	3	-	Accepted	-
6	1	Accepted	Accepted	Partial
	2	-	Partial	-
	3	-	Accepted	-
7	1	Accepted	Accepted	Full
	2	-	Partial	Full
	3	-	Accepted	Full
8	1	Accepted	Full	Full
	2	-	Accepted	Accepted

	3	-	Accepted	Accepted
9	1	Accepted	Accepted	Accepted
	2	-	Accepted	Accepted
	3	-	Accepted	Accepted
10	1	Accepted	Accepted	-
	2	-	Accepted	-
	3	-	Accepted	-
11	1	Accepted	Full	Accepted
	2	-	Full	Accepted
	3	-	Accepted	Accepted
12	1	Accepted	Accepted	Accepted
	2	-	Accepted	Accepted
	3	-	Accepted	Accepted
13	1	Partial	Full	Full
	2	-	Partial	-
	3	-	Full	-
14	1	Accepted	Full	Accepted
	2	-	-	Full
	3	-	-	-

Figure C1

False Memory Formation over Time for Each Condition