Exploring the Consequences of Nonbelieved Memories in the DRM Paradigm

Henry Otgaar[1,2], Georgiana Moldoveanu[1], Jianqin Wang[2], and Mark L. Howe[1,2]

[1]Maastricht University, The Netherlands

[2]City, University of London, UK

Words (main text): 8664

Correspondence to Henry Otgaar, Clinical Psychological Science, Faculty of Psychology and Neuroscience, Maastricht University, PO Box 616, 6200 MD, Maastricht, the Netherlands, Tel.: +31-43-3884340, Fax: +3143-3884196. E-mail address: Henry.Otgaar@maastrichtuniversity.nl

IN PRESS: *Memory*

Abstract

In the current experiments, we attempted to elicit nonbelieved memories using the Deese/Roediger-McDermott (DRM) false memory paradigm. Furthermore, by using this approach, we explored the consequences of nonbelieved true and false memories. In Experiments 1 and 2, participants received several DRM wordlists and were presented with a recognition task. After the recognition task, participants' statements were contradicted by giving them feedback about true and false items. In this way, we succeeded in eliciting nonbelieved true and false memories. In Experiment 2, participants were also involved in a modified perceptual closure task after receiving belief-relevant feedback. In this task, participants received degraded visual representations of words (e.g., false and true) that became clearer over time. Participants had to identify them as fast as possible. We also measured dissociation, compliance, and social desirability. We found that undermining belief had contrasting consequences for true and false memories. That is, nonbelieved true memories were identified more slowly whereas nonbelieved false memories were identified more quickly. We did not find any relation between our individual differences measures and the formation of nonbelieved memories.

Keywords: nonbelieved memories; autobiographical belief; false memory; DRM

Exploring the Consequences of Nonbelieved Memories in the DRM Paradigm

Our behavior is guided by previous experiences. Think, for example, about those occasions that you do not want to talk to a friend because you just had an argument with them. Or that you avoid dogs because of an adverse experience in your childhood when a pitbull had bitten you. On such occasions, our previous experience determines how we react in the future. That is, the past is used not just to interpret current experiences but also to anticipate the future. An unresolved question is whether our behavior is predominantly affected by the *recollection* of a previous experience or by the *belief* that a previous experience occurred. The current set of studies explored the independent and combined consequences of belief and recollection on behavior.

Documentation of which precursors affect behavior has frequently concentrated on the impact of autobiographical memory on behavior (e.g., Bluck, 2015; Nelson, 1993). However, recent research has emphasized that the majority of previous memory research has focused squarely on the examination of *believed memories* (Scoboria et al., 2014). By doing so, memory researchers have, perhaps unintentionally, neglected to accurately distinguish between *belief* and *recollection*. Distinguishing between these constructs is important because a new line of research has shown that belief and recollection are distinct constructs (e.g., Mazzoni & Kirsch, 2002; Otgaar, Howe, Clark, Wang, & Merckelbach, 2015; Scoboria, Mazzoni, Kirsch, & Relyea, 2004).

According to this new research, (autobiographical) belief refers to the truth-value associated with the occurrence of an event, whether or not recollection is present, whereas recollection refers to the mental re-experiencing of an event (e.g., Rubin, 2006; Scoboria et al., 2014). Although in the majority of cases, both belief and recollection co-occur, there are numerous cases in which only autobiographical belief exists in the absence of recollection. Take for example your first birthday. Obviously, you believe that this event occurred but you have no recollection of this event.

Theories about implanted false memory stress that when suggestion about fictitious events are provided, belief in occurrence must also start and typically does so prior to the emergence of false recollections (Mazzoni, Loftus, & Kirsch, 2001; Pezdek, Finger, & Hodge, 1997; Scoboria et al., 2004). Numerous studies demonstrate that false beliefs can develop without accompanying increases in false recollection (Bernstein, Pernat, & Loftus, 2011; Hart & Schooler, 2006; Mazzoni, Loftus, Seitz, & Lynn, 1999; Pezdek, Blandon-Gitlin, & Gabbay, 2006; Scoboria, Wysman, & Otgaar, 2012). Moreover, there are studies showing moderate correlations between autobiographical belief and recollection where belief ratings often surpass recollection ratings (Scoboria et al., 2004; Sharman & Scoboria, 2009). Of interest for the current experiments are recent studies showing that there are instances in which people develop recollections of events for which the belief in the occurrence of these events is undermined. These memories are called nonbelieved memories (Otgaar, Scoboria, & Mazzoni, 2014).

Nonbelieved memories (NBMs) run counter to the idea that when events are recollected, belief in the occurrence of those events is present as well. In the psychological literature, anecdotal reports of NBMs have sometimes been reported. These reports range from, for example, Jean Piaget remembering, but not believing, that he was kidnapped in his childhood (Piaget, 1951) to more serious examples where innocent suspects continue to remember having committed a crime while simultaneously not believing the event occurred (Brainerd, 2013). Apart from these anecdotal reports, research in the area of NBMs is relatively scarce. The first empirical demonstration on naturally occurring NBMs was conducted by Mazzoni, Scoboria, and

Harvey (2010). In this study, they tested a large sample of participants in order to identify people with specific NBMs and found that approximately 20% of participants indicated they had a NBM.

Based on this pioneering work (see also Scoboria & Talarico, 2013), researchers became interested in the experimentally elicitation of NBMs in the laboratory. Because social feedback is considered to be the most important factor to lead to NBMs (Scoboria, Boucher, & Mazzoni, 2015), experimental paradigms were selected that used social feedback to engender false memories. The rationale was that NBMs could be created in these false memory paradigms when participants were told that their false memories were incorrect. Otgaar, Scoboria, and Smeets (2013) experimentally evoked NBMs for childhood events using a false memory implantation paradigm. In two experiments, they falsely suggested to adults (Experiment 1) and 10-year old children (Experiment 2) that they were on a hot air balloon ride in their childhood. Across two suggestive interviews, both adults and children produced false memories of the hot air balloon experience. Crucially, after these interviews, participants were debriefed and informed that their false memory was flawed. The intriguing finding was that 40% of those with false memories reported to have a NBM post-debriefing (for related findings, see Clark, Nash, Fincham, & Mazzoni, 2012; Mazzoni, Clark, & Nash, 2014; Otgaar, Scoboria, Howe, Moldoveanu, & Smeets, 2016).

Empirical work in the area of belief and recollection has shown that NBMs are not as rare as once assumed and that they can be set up in an experimental manner. An unsettled question, however, is whether our behavior is guided by belief, by recollection, or both. Up until now, no studies have looked at this, but the question is highly relevant. Indeed, as Nash, Wheeler, and Hope (2015) formulated: “one interesting and as-yet-unanswered empirical question is whether memories per se do indeed guide behavior, or whether it is the belief in the occurrence of those remembered events that is the active agent" (p. 320). One of the purposes of the present experiments is to dig into this question and explore whether it is belief, recollection, or both that contribute to behavior.

A burgeoning literature exists on the consequences of false beliefs and memories for food preferences and choices (Bernstein & Loftus, 2009). The question of whether the effects of false feedback on food preferences and choices could be fully accounted for by increases in belief or memory has recently been addressed (Bernstein, Scoboria, & Arnold, 2015). By combining data from eight published experiments (N = 1369), the authors found that belief in occurrence predicted changes in food preferences and behavior intentions, and that memory did not add additional variance. This finding suggests that belief, not memory, is the operating vehicle for changes in behavior.

In another line of work, researchers have looked at the *positive* consequences of false memories (Howe, 2011). In these experiments, researchers have used a powerful and robust procedure to elicit false memories, the Deese/Roediger-McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995). Here, participants receive wordlists containing associatively-related concepts (e.g., *tears, bed, child*) that are linked to a non-presented critical lure word (i.e., *cry*). Recall and recognition measures show that a significant number of participants falsely recollect the critical lure (Otgaar, Peters, & Howe, 2012).

Recent experimentation has used the DRM paradigm to test whether false memories might prime solutions on various problem-solving tasks. For example, Howe, Garner, Charlesworth, and Knott (2011) presented children and adults with DRM wordlists. The critical lures on these lists also served as the solutions to compound remote associate task (CRAT) problems. These CRATs were presented after the encoding of the DRM wordlists. Interestingly, problem solving was easier and faster for false than true memories thereby demonstrating that false memories are more beneficial than true memories when priming solutions to problems.

We have recently shown that false memories can even prime tasks linked to intelligence (Otgaar et al., 2015). In two experiments, participants were visually presented with DRM wordlists and received a recognition task. After this, participants received a modified perceptual closure task. In this task, participants were presented with degraded visual representations of words (false, true, and unrelated items) that became clearer over time. Participants had to provide identifications as soon as possible. Such a task is linked to certain subtasks of intelligence tests in which degraded pictures are presented and participants have to come up with an answer as soon as possible (e.g., Luteijn & Barelds, 2004). We found that false memories were identified faster than true memories and unrelated items. Again, these data imply that in certain situations, false memories can have positive consequences.

The current experiments have two aims. First, because no experimental work has been done on the consequences of NBMs (but see also Wang, Otgaar, Howe, Smeets, Merckelbach, & Nahouli, in press), we explored the consequences of NBMs on a PCT task. Second, to examine this issue, we decided to use the DRM paradigm to elicit NBMs. Although the DRM paradigm has not been used before to elicit NBMs, it is an excellent method to do so. That is, in the DRM paradigm, robust and high levels of true and false memories are simultaneously elicited (Roediger, Watson, McDermott, & Gallo, 2001) and this situation grants the possibility to successfully induce NBMs. Indeed, previous work from our lab (Otgaar et al., 2016) has adapted the imagination inflation paradigm to elicit NBMs. In the imagination inflation paradigm, both true and false memories are evoked and NBMs are easily created. Hence, our prediction would be that NBMs could potentially be elicited in the DRM paradigm. Experiments 1 and 2 were conducted to examine whether the DRM paradigm could be employed to create NBMs. To foreshadow our findings, the answer is yes. That is, we show that the DRM paradigm can be used to elicit both nonbelieved true and nonbelieved false memories.

In Experiment 2, we also explored the behavioral consequences of NBMs. We used the perceptual closure task as a proxy for a behavioral task to examine these consequences. The reason for choosing this task was the following. First, previous work using CRATs is somewhat limited as the CRAT procedure still resembles a DRM procedure (i.e., presentation of words that are associatively related to the solution word). We wanted to use a task that was not similar to a DRM task but which could be still used to examine the consequences of NBMs. Second, a perceptual closure task is in essence a picture completion task and parallels certain subtasks of intelligence in which degraded pictures need to be identified as fast as possible (Luteijn & Barelds, 2004). Here, participants were first presented with DRM lists and then received a recognition task. Next, participants received feedback about certain items suggesting that the items were not presented. This was done to create NBMs. Following this, participants had to complete the perceptual closure task. Because this is the first study looking into the aftereffects of NBMs, no strong predictions could be made. However, based on earlier work on the effects of false beliefs on food preferences (Bernstein & Scoboria, 2015), one prediction would be that when belief is undermined, this adversely impacts the performance on the perceptual closure task. The reasoning behind this is that belief drives behavioral consequences even on tasks such as the perceptual closure task. Specifically, according to this prediction, nonbelieved true and false memories would prime identifications to a lesser extent than believed true and false memories. On the other hand, if the perceptual closure task is regarded as a recognition or identification task, something that implies that participants need a recollection to successfully complete the task, then when belief is undermined, this would not affect identification performance. Furthermore, this would imply that items that are believed, but not recollected, would be worse primes on the perceptual closure task compared to nonbelieved true and false memories.

We were also interested in some other exploratory goals. First, Mazzoni and colleagues (2010) showed that NBMs were more likely to contain negative emotions. Hence, in the current experiments, we used neutral and negative DRM lists to explore the consequences of emotion and NBMs on behavior. Second, as previous work has consistently looked at phenomenological features of NBMs (visual, auditory details, etc.; e.g., Mazzoni et al., 2010), we examined these features as well. Third, our knowledge about which persons might be at high risk to create NBMs is limited. Hence, in Experiment 2, we added several individual differences scales. Because social feedback is regarded as one of the main contributors to NBMs (Scoboria et al., 2015), we included compliance and social desirability scales. Furthermore, NBMs are less connected to other memories, implying a lower sense of self, which can be associated with certain types of dissociative experiences (e.g., derealization). Thus, a dissociation scale was included as well.

Experiment 1

Method

Participants

Twenty-seven students from the Faculty of Psychology and Neuroscience, Maastricht University participated voluntarily in this experiment in exchange for credit points or a financial reimbursement. One participant was excluded due to misunderstanding the instructions, thus leaving a total of 26 participants (30% male, 70% female) for the subsequent analysis. All participants were undergraduate students, fluent in English, aged between 18 and 34 (M_{age}= 22.58, *SD* = 3.46). Participating in a similar memory-related study was considered an exclusion criterion. The experiment was approved by the ethical committee of the Faculty of Psychology and Neuroscience, Maastricht University.

Materials

DRM Lists We used 12 DRM lists (6 neutral and 6 negative) in this experiment. These lists have successfully been used in previous research (Howe, Garner, & Patel, 2013). Each of the DRM lists consisted of 10 words (list example: door, glass, pane, shade, ledge, sill, house, curtain, view, screen) and a non-presented target or "critical lure" (e.g., window). The words were presented as audio files by means of a PowerPoint presentation, with a tempo of 1.5 seconds per word and a 1.5 seconds break between the lists. The audio files were recorded with the help of a native English-speaking student.

The recognition task contained 108 words. Of these words, 48 were hits that were presented in the DRM lists (e.g., door, pane, ledge, house), 12 were critical lures (e.g., window), and 48 words were not presented and unrelated (e.g., daisy, pine, leaf, root) items. The presented words used in this task were taken from first, third, fifth, and seventh positions in the DRM lists.

Memory Characteristics Questionnaire An adapted six-item (7-point Likert scale) version of the Memory Characteristic Questionnaire (MCQ; Johnson, Foley, Suengas, & Raye, 1998) was used to compare phenomenological ratings of different types of memories elicited (true; false; nonbelieved true; nonbelieved false; believed-non-remembered true and believed-non-remembered false memories). The selected items were about clarity, visual details, sound, vividness, event detail, and tone of the memories (-/+). Another 7-point Likert scale item regarding familiarity was added (i.e., "This word is for me" with answers from "*not at all* *familiar*" to "*very familiar*"). These items were chosen to assess key features associated with recollection in prior work and for their relevance to the characteristics of this study.

Design and Procedure

We used a 2 (Emotion: Neutral vs. Negative) x 2 (Challenge: Yes vs. No) within-participant design. Participants were tested individually for approximately 90 minutes each in lab facilities at the faculty. They were first presented with the neutral and negative DRM lists in a counterbalanced fashion and instructed to listen and memorize the words from the lists. After this, a short filler task (i.e., find the differences) for 5 minutes was completed. Following this, participants received the recognition task. In this task, participants were instructed to think of the words presented on the lists and circle "*yes*" if they remembered the words and "*no*" if they did not remember them. If a word was remembered, participants had to provide memory and belief ratings on a 8-point scale (i.e., "Do you have a memory for this word?" with answers ranging from "*no memory at all*" to "*clear and complete memory*"; and "Do you believe that this word was presented to you?" with answers ranging from "*definitely did not happen*" to "*definitely did happen*"; Scoboria et al., 2004). When a word was not recognized as presented, the participants had to circle the answer "*no*" and move on to the next word.

After the recognition task was completed, the experimenter checked the participants' answers and offered feedback regarding the accuracy of the answers. That is, some words were challenged regarding their presence on the DRM lists, regardless of whether the answers were correct or not. For example, the word "*window*" was a critical lure in this experiment. If the participants recognized it, then the experimenter challenged their answer by saying that this was not true (i.e., "it was not present on the lists"). In this case, we attempted to create nonbelieved false memories. The same situation occurred, for example, for the word "*pane*", which was presented in the lists, but challenged as well in case it was recognized by the participant. In this case, the experimenter deliberately deceived the participants to elicit nonbelieved true memories. As in previous research, NBMs were scored when the belief rating was 2 points lower than the memory ratings (e.g., Clark et al., 2012).

The challenge was done using two predetermined series of words. Importantly, in this experiment, words were challenged only if the participant recognized, correctly or falsely, the specific word. Verbal feedback was provided, alongside false external evidence in the form of a fake written proof. The experimenter wrote down the answers. The fake proof consisted of a fake transcript of the audio files (i.e., lists) and the words written in the same order as in the recognition task and with "*no, not presented*" or "*yes, presented*" reported next to each word.

As mentioned, there were two predetermined series of words used for the challenge that were counterbalanced together with the two sets of DRM wordlists (i.e., neutral and negative). The predetermined series of challenged words consisted of half of the critical lures (6 in total with 3 neutral and 3 negative) and 12 presented items (6 neutral and 6 negative). The presented items used for the challenge were taken from the third position in the DRM lists. After the challenge, participants had to provide memory and belief ratings once more and were also asked to provide ratings on certain MCQ items again. The number of remembered words varied across participants, thus the number of challenges and the number of words with memory characteristics recorded also varied per participant in this experiment. While the experimenter checked the answers from the recognition task, participants had to complete another, similar, filler task (5 minutes). At the end, the participants were debriefed and given a form with more details about the experiment.

Results and Discussion

Recognition Task

Regarding the answers on the recognition task, a repeated measures ANOVA showed that negative hit rates (*M* = 0.76, *SD* = 0.16) were statistically higher than neutral hit rates (*M* = 0.68, *SD* = 0.16; $F(1, 25) = 7.07$, $p = .01$, $\eta_{partial}^2 = .22$). No statistical differences were found for false recognition (negative: *M* = 0.73, *SD* = 0.25; neutral: *M* = 0.69, *SD* = 0.17; $F(1, 25) = 0.57$, $p = .46$, $\eta_{partial}^2 = .02$).

Rates of Different Memory Types

Before the challenge, all participants had true memories (i.e., hits; *N* = 26, min 1 – max 11, *M* = 6.27, *SD* = 2.78) and 92% (*N* = 24, *M* = 2.69, *SD* = 1.49, min 1 - max 5) had at least one false memory. Also, there were some cases of spontaneous NBMs that were elicited without the event being challenged for 42.3% of the participants (*N*= 11, *M*= 2.19, *SD*= 4.09, min 1- max 16). Out of these, 34.6% of the participants (*N* = 9, *M* = 1.31, *SD* = 2.85, min1 - max 13) had at least one spontaneous nonbelieved false memory and 34.6% (*N* = 9, *M* = .88, *SD* = 1.72, min 1 - max 7) had at least one spontaneous nonbelieved true memory.

The most important findings refer to whether participants created nonbelieved memories in the DRM paradigm after being challenged. After being challenged, several memory types could occur. Participants could accept the challenge leading to nonbelieved memories, believed, non-remembered events, or nonbelieved, non-remembered events. As the challenges in this case occurred only if the words were recognized as presented, 25.43% of the events were challenged (*N* = 333, *M* = 12.81, *SD* = 3.00, range 7-17). The challenges were rejected (i.e., participants did not go along with the challenge) in 72.07% of the cases (*N* = 240, *M* = 9.23, *SD* = 3.44, with a minimum of 3 rejections per participant and a maximum of 16; all participants had at least one rejection), accepted in 27.74% of the cases (*N* = 93, *M* = 3.58, *SD* = 2.85). In general, after the challenges irrespective if the challenge was accepted or rejected, there were 69.97% (233/333 x 100%) believed memories (*N* = 233, 70 false, 163 true memories), 9.9% nonbelieved memories (*N* = 33, 24 true, 9 false), 2.1% believed, non-remembered (*N* = 7, 6 true, 1 false) and 18% nonbelieved non-remembered events (*N* = 60; see Table 1). If we look specifically at rates of different memory types for accepted challenges, then we find the following: nonbelieved memory true: *n* = 21, nonbelieved memory false: *n* = 9, believed, not remembered true: *n* = 4.

Additionally, out of the total number of nonbelieved memories, 33.3% were negative (*N* = 11, 9 true, 2 false) and the rest were neutral (*N* = 22, 15 true, 7 false). No statistically significant difference was found between neutral and negative NBMs.

[Table 1 here]

Memory Characteristics

Purely for exploratory purposes, we also conducted univariate analyses with Bonferroni correction on the different phenomenological features (e.g., clarity) of the different memory types. For clarity, we only found that true memories (hits; *M* = 4.71, *SD* = 1.44) received statistically higher clarity ratings than false memories (*M* = 3.50, *SD* = 1.65; *p* = .004; *F*(5, 114) = 2.98, *p* = .01, η_{partial}^2 = .12). This effect was also evident for visual details. Visual details were higher in true (*M* = 4.50, *SD* = 1.43) than in false memories (*M* = 3.31, *SD* = 1.55, p = .004; *F*(5, 114) = 3.45, *p* = .006, η_{partial}^2 = .13). No statistical differences were found for sound, vividness, event detail, tone of memory, or familiarity.

The results from Experiment 1 clearly show that the DRM paradigm can be used to elicit NBMs. As can be seen, we succeeded in evoking NBMs in about 10% (*n* = 33) of the items that were challenged. This percentage is quite similar to percentages in previous experiments (e.g., 8.33%; Mazzoni et al., 2014). Furthermore, we showed that other memory types (e.g., believed memories, believed not remembered) could be induced as well and revealed that nonbelieved true memory rates were descriptively higher than nonbelieved false memory rates.

Because Experiment 1 confirmed that the DRM paradigm could evoke NBMs, Experiment 2 was conducted to replicate this and explore the behavioral consequences of NBMs by using a perceptual closure task. To make sure we created a sufficient number of NBMs to perform meaningful analyses and because several observed null effects (e.g., the effect of emotion on NBM formation) might be due to low power, we doubled our sample size. Also, in Experiment 1 the number of challenges could vary between participants and this could have led to some participants creating more NBMs than others. Hence, we changed this in Experiment 2 by providing participants with a fixed number of challenges.

Experiment 2

Method

Participants

We tested 52 participants, with one excluded due to misunderstanding the instructions. Out of the 51 participants left, 18 were male and 33 female, with age ranging from 18 to 35 years old (M_{age}= 21.63, *SD*= 2.93). All participants were undergraduate students at Maastricht University, except one that had a PhD position. All participants were fluent in English and received credit points or a financial reimbursement for their participation. No participant took part in a similar memory experiment or in the previous experiment.

Materials

DRM Lists The same DRM lists and recognition task were used as in Experiment 1. The words were visually presented and the presentation was constructed in PowerPoint 2010 using pictures of the words to be presented. We had to provide words visually and not verbally (as in Experiment 1) because the perceptual closure task is a picture completion task. The pictures were created using Adobe Photoshop CS5, with the words displayed in the "Calibri" font, size "125pt" and picture resolutions of 1680x1050, font color black on a white background. Presenting the lists as visual stimuli was done to parallel the perceptual closure task, which contained visual representations of words.

Perceptual Closure Task A digitalized perceptual closure task (PCT) was used including 84 words in total (see also Otgaar et al., 2015). Twenty-four of these words were presented in the DRM lists and in the recognition task (i.e., hits), 24 were presented only in the lists but not included in the recognition task (i.e., hits new), 12 were the critical lures, 12 were non-presented unrelated words that were in the recognition task as well (i.e., unrelated) and 12 non-presented unrelated words that were new (i.e., unrelated new). The words were displayed as pictures (10 for each word) containing a distortion filter that becomes clearer over time. This task measures the accuracy and the reaction times for the recognition of the words using the software E-Prime 2.0. The distorted pictures were created using free software, GIMP 2.0 (we used the filter Blinds (Distorts) option in GIMP 2.0 and used a horizontal displacement of 90 and n segments at 25, 25, 40, 45, 55, 65, 70, respectively 95. The next filter had a displacement of 70 and an n segment of 100). The last picture was the one originally created using Adobe Photoshop CS5. Out of the 24 words that were presented in the lists and in the recognition task, 12 were challenged, thus adding a high probability of including NBMs in the PCT. Half of the critical lures were also challenged. The challenged words represented maximum 21.5% of the total of words that the PCT contained.

Individual Differences

Dissociative Experiences Scale (DES; Bernstein & Putman, 1986) The DES is a self-report measure that assesses the degree to which individuals experience dissociation. It consists of 28 items. Furthermore, on a visual analogue scale, participants have to indicate how frequently they experience dissociative symptoms. Examples of items are “Some people have the experience of finding themselves in a place and having no idea how they got there” or “Some people are told that they sometimes do not recognize friends or family members**”.** The scale is ranging from 0% (*Never*) to 100% (*Always*) in 10% increments. The total score is the mean of all items and it is ranging from 0 to 100. It has a good internal consistency with Cronbach α= .92.

Gudjonsson Compliance Scale (GCS; Gudjonsson, 1989, 1997) The GCS consists of 20 statements answered true or false and it is constructed as a self-report questionnaire (examples of items: “I give in easily when I am pressured” or “I tend to go along with what people tell me even when I know that they are wrong”) measuring compliance (Gudjonsson & Sigurdsson, 2003). Each answer that suggests compliance is scored with one point. After administering, scores are summed (range 0-20), with higher scores reflecting more compliant behavior. The GCS has good reliability, an internal consistency-of .71 and a test-retest reliability coefficient of .88 (Gudjonsson, 1997).

Marlowe-Crowne Social Desirability Scale (MC-SDS; Crowne & Marlowe, 1960) The MC-SDS was designed to measure social desirability independent of psychopathology. The scale assesses whether respondents are answering truthfully or are misrepresenting themselves in order to manage their self-presentation. The scale has 33 items using a true/false response format (e.g.

“I never hesitate to go out of my way to help someone in trouble”, “It is sometimes hard for me to go on with my work if I am not encouraged”). Crowne and Marlowe (1960) showed that the internal consistency is .88, and the test-retest correlation .89.

Design and Procedure

A 2 (Emotion: Neutral vs. Negative) x 2 (Challenge: Yes vs. No) within-participant design was used. Participants were tested individually and were presented with all tasks in four counterbalanced orders (similar to Experiment 1), in an approximately 120-minute session each.

First, participants were presented with the DRM wordlists and asked to memorize the words. Next, participants received the recognition task. After the recognition task was completed, the experimenter checked the answers and challenged certain items by giving verbal feedback. In this experiment, we presented participants with a fixed number of challenges according to two predetermined sets of words. Because the number of challenges was fixed, it could be that items that were not recognized were also challenged (i.e., here it was said that the item was presented). In other words, a word was challenged whether it was recognized as presented or not presented by the participant. However, although items could be challenged whether recognized or not, in line with previous work on nonbelieved memories (e.g., Otgaar et al., 2016), in this experiment, we were only interested in and only report on the data of items that *were* recognized *and* challenged. As research has shown that social feedback is the most often reported reason leading to the formation of nonbelieved memories (e.g., Mazzoni et al., 2010), and because in Experiment 1 our impression was that the fake proof did not add substantially to our challenge manipulation, we also made the following change in the procedure. So, the written fake proof was not used anymore and only social feedback was given in Experiment 2. Memory characteristics were asked only for the words that were recognized.

After the recognition task and all challenges, participants engaged in the perceptual closure task. In this task, they had to press a button as soon as they recognized the distorted words, followed by digitally writing what they believed the word was that they identified. The words were successively presented. In between each task participants were given a filler task (i.e., find the differences). Finally, participants had to fill in the questionnaires regarding individual differences. The order of the questionnaires was kept the same for all participants. After filling in the questionnaires, participants were debriefed.

Results and Discussion

Recognition Task

Out of the items presented in the recognition task, a repeated measures ANOVA revealed that participants had statistically higher negative (*M* = 0.80, *SD* = 0.15) than neutral hit rates (*M* = 0.73, *SD* = 0.16; $F(1, 50) = 6.20$, $p = .02$, $\eta_{partial}^2 = .11$). Also, negative false memories (*M* = 0.67, *SD* = 0.25) were statistically higher compared to the neutral false memories (*M* = 0.54, *SD* = 0.27; $F(1, 50) = 10.45$, $p = .002$, $\eta_{partial}^2 = .17$).

Rates of Different Memory Types

Before the challenge, almost all participants had true memories[1] (*N* = 50, min 1 – max 14, *M* = 7.88, *SD* = 2.60) and 88.2% (*N* = 45, *M* = 3.04, *SD* = 2.02, min 1- max 7) had at least a false memory. Also, there were some cases of spontaneous NBMs that were elicited without the event being challenged for 35.3 % of the participants (*N* = 18, *M* = 1.24, *SD* = 2.23, min 1- max 9). Out of these, 21.6 % of the participants (*N* = 11, *M* = .41, *SD* = 1.02, min1- max 6) had at least one nonbelieved false memory and 27.4 % (*N* = 14, *M* = .82, *SD* = 1.57, min 1-max 6) had at least one nonbelieved true memory.

The crucial finding was the number of nonbelieved memories that were created after participants were challenged. As for the challenged items, there were 18 challenges per participant (17 for one participant). The total number of challenges was 917 (i.e., (18 x 51)-1), with 655 (71.4%) challenged items that were recognized as presented (challenged yes, *M* = 12.84, *SD* = 2.51, min 7 - max 18, all participants) and 262 (28.6%) challenged items that were not recognized, but still challenged (challenged no, *M* = 5.15, *SD* = 2.51, min 0 - max 11, for 50 participants). The challenges were rejected in 64.8% of the cases (*N* = 594, *M* = 11.65, *SD* = 3.68, min 2-max 18, all participants had at least one rejection), accepted in 35.2% of the cases (*N* = 323, *M* = 6.33, *SD* = 3.72, min 0 - max 16).

Regarding the memory type status after the challenges for items that were recognized and challenged, there were 16.8% non-believed-non-remembered events reported (58 retracted memories, 96 still not remembered), 73.3% (480/655 x 100%) believed memories (*N* = 480, 117 false, 363 true that were rejected challenges), 13.13% nonbelieved memories (*N* = 86, with 54 true, 32 false accepted challenges) and 4.4% believed-non-remembered (*N* = 29, with 13 true, 16 false accepted challenge; see also Table 2). Like Experiment 1, no statistical difference was found between neutral and negative NBMs

[Table 2 here]

Perceptual Closure Task

We start by reporting the most important findings. To reiterate, we only examined the PCT data of memory types for items that *were* recognized *and* challenged. Reaction time data are reported in milliseconds (i.e., ms). Outliers were removed from the analyses. In total, 34 outliers (i.e., reaction time responses) were detected and removed by trimming the data by standard deviations (+/- 2SD; Ratcliff, 1993). Before we could start analyzing the data, we filtered the data (see also Otgaar et al., 2015). That is, cases that were incorrectly recognized were removed from the perceptual closure task. For example, if a participant pressed the button indicating recognition of a word (e.g., house) but then filled in an incorrect response (e.g., mouse), then this was removed from the analyses. Of a total of 4284 answers that could be provided, 5.6% were incorrect (n = 241) and 93.3% (n = 3998) were correct; the rest were cases in which a button was pressed but no answer was typed (n = 45). As has been mentioned earlier, in Experiment 2, we used a fixed number of challenges whatever the response of the participants (recognized or not). As has been done in earlier work (e.g., Otgaar et al., 2015), for the analyses, we looked at those challenged items that were (correctly or falsely) recognized by participants.

To examine the consequences of NBMs on the identification performance of the perceptual closure task, we conducted several analyses. Imputation analyses were performed to deal with missing data (Van Ginkel & Van der Ark, 2005). When we performed a repeated measures ANOVA on different memory types (true memory (hits); false memory; nonbelieved true; nonbelieved false; believed, not-remembered true; believed, not-remembered false), we found a statistically significant effect of memory type ($F(2.31, 115.40) = 28.41$, $p < .001$, $\eta_{partial}^2 = .36$; Greenhouse-Geisser correction).[2] Post-hoc Bonferroni tests revealed the following. Nonbelieved false memory items were identified statistically faster than all other memory types except for the false memory items (ps < .0001). In contrast, except for the believed, not-remembered true items, nonbelieved true memory items were identified statistically slower than all other items (ps < .03). This was also true for believed, not-remembered true items: they were also identified slower than all other memory types (ps < .001). Finally, we found that believed, not-remembered false items were identified statistically slower than nonbelieved false memories

($p < .001$). So, undermining belief has different consequences for true and false memories (Figure 1).

Because the different memory types were unequally distributed among participants, we also conducted a mixed-model analysis on the data (Cnaan, Laird, & Slasor, 1997; West, Welch, & Galecki, 2007). A roughly similar pattern was observed as reported before. A main effect of memory types was observed ($F(5, 136) = 3.70$, $p = .004$). Again, identifications were statistically faster for the nonbelieved false memory items than for true memory, nonbelieved true memories, and believed, not-remembered true items (ps < .03). Furthermore, we found higher reaction times (slow identification) for the nonbelieved true memory items than (nonbelieved) false memory items (ps < .02). Once more, we found support that believed, not-remembered true items were slower identified than all other memory types (ps <. 03) except for the nonbelieved true items.

[Figure 1 here]

Exploratory Analyses

Emotion We also explored whether our effects would be different for neutral and negative true and false memories (and NBMs). However, when we added the factor Emotion in the mixed-model, the effect was not statistically significant ($F(1, 223) = 0.29$, $p = .59$).

Memory Characteristics As in Experiment 1, we found that true memories ($M = 4.87$, $SD = 1.54$) were experienced as having more clarity than false memories ($M = 3.92$, $SD = 1.67$, $p = .002$; $F(5, 237) = 5.78$, $p < .001$, $\eta_{partial}^2 = .11$), nonbelieved true memories ($M = 3.59$, $SD = 1.29$, $p = .001$), and believed, not-remembered true items ($M = 3.13$, $SD = 1.38$, $p = .04$). Also, visual details were statistically ($F(5, 237) = 5.44$, $p < .001$, $\eta_{partial}^2 = .10$) more present in true

(*M*= 4.64, *SD* = 1.61) than in false memories (*M* = 3.69, *SD* = 1.66, $p = .003$) and nonbelieved true memories (*M* = 3.40, *SD* = 1.47, $p = .046$).

For vividness ratings, believed, not-remembered false items (*M* = 3.96, *SD* = 2.51) were experienced as more vivid ($F(5, 237) = 5.09$, $p < .001$, $\eta_{partial}^2 = .10$) than true memories (*M* = 2.48, *SD* = 1.55, $p = .03$), false memories (*M* = 2.11, *SD* = 1.41, $p = .003$), nonbelieved true (*M* = 1.56, *SD* = 1.10, $p < .001$), and nonbelieved false memories (*M* = 2.21, *SD* = 1.77, $p = .03$). We also found that false memory items (*M* = 6.05, *SD* = 1.13) were rated as more familiar ($F(5, 237) = 5.10$, $p < .001$, $\eta_{partial}^2 = .10$) than true memories (*M* = 5.39, *SD* = 1.22, $p = .03$) and believed, not remembered true items (*M* = 4.38, *SD* = 2.62, $p = .01$). No statistically significant differences were found for sound, details, and tone of memory.[2]

To conclude, we again showed that the DRM paradigm can successfully be used to experimentally induce nonbelieved memories. Furthermore, we found that surrendering belief has differential effects for true and false memories. That is, whereas nonbelieved false memories were identified faster on the PCT, nonbelieved true memories were identified much slower than most of the other memory categories. We will discuss the relevance of these findings next.

General Discussion

In the current experiments, we examined whether NBMs could be created when using the DRM paradigm. Specifically, in Experiments 1 and 2, we assessed whether the DRM paradigm could be used to induce nonbelieved true and false memories. Our data showed that we were successful in this endeavor. Experiment 2 was conducted to explore the ramifications of NBMs on a modified perceptual closure task. We found that undermining belief had opposing consequences for true and false memory.

Our most consistent finding of the current experiments was that reliable levels of NBMs could be elicited when relying on the DRM paradigm. Indeed, after being challenged, we found comparable levels of nonbelieved memories in both experiments (Experiment 1: 9.9% (*n* = 33); Experiment 2: 13.13% (*n* = 86). That the DRM paradigm can be used to experimentally evoke nonbelieved memories is important because previous work has revealed that the elicitation of NBMs is quite challenging (e.g., Otgaar et al., 2013). Hence, it is important to look for new ways to undermine belief and elicit NBMs. The advantage of procedures such as the DRM paradigm is that each participant can create many true and false memories and this creation increases the chances of multiple NBMs within one participant. Indeed, we have recently evoked NBMs by using an adaptation of an imagination inflation procedure (Otgaar et al., 2016). In that study, participants had to perform, imagine, and heard action statements (e.g., break the toothpick), imagined certain actions multiple times, and received a recognition test two weeks later. Here too, many true and false memories could be produced within a participant and after being challenged, we found, as in the current experiments, that NBMs could be elicited.

In Experiment 2, we also explored the consequences of NBMs on a perceptual closure task. Although we should be careful in interpreting our findings, the results from Experiment 2 imply that undermining belief has contrasting consequences for true and false memories. Specifically, when participants' true and false recollections were challenged and ended up in nonbelieved true and false memories, a divergent pattern of PCT results emerged. Nonbelieved false memory items were better (i.e., more quickly) identified than most of the other memory types. By contrast, our analyses showed that for nonbelieved true memory items, identifications became worse and thus slower than many other memory types.

What this implies is that for false memories, when belief is undermined and recollection remains intact, performance on the PCT improves in that it leads to faster reaction times. Previous research has already provided proof that when using tasks such as the ones we used combined with the DRM paradigm, false memories prime problem solutions (e.g., identifications) much better than true memories (e.g., Howe, Threadgold et al., 2013; Howe et al., in press; Otgaar et al., 2015). These findings have fuelled the idea that under many circumstances, false memories can have many beneficial outcomes. That recollection is vital for affecting behavioral consequences can also be seen in the identification performance of believed, not-remembered false memories. They were identified statistically slower than nonbelieved false memories suggesting again that it is recollection, and not belief, that drives the behavioral consequences of false memories.

For true memories, we found the completely opposite pattern. Here, we showed that when belief was undermined leading to nonbelieved true memories, identifications were made much slower than other memory types. This indicates that for true memories, belief is a crucial factor in guiding behavior on the PCT. Furthermore, this result corresponds well with recent research showing that behavioral tasks such as food choices and preferences were determined by belief and not recollection (Bernstein et al., 2015). However, we also found that believed, not-remembered true items were identified much slower than, for example, true memories. This seems to be in contrast with the idea that belief is the most important element in completing the PCT.

The finding that belief is important for true memories is in line with a recent study (Wang et al., in press) on the consequences of NBMs on behavior. In this study, nonbelieved memories were also elicited using the DRM paradigm and then participants received insight-based problems in the form of CRATs (Howe et al., 2010). Like our Experiment 2, the findings from their second experiment also suggested that when belief was undermined for true memories, fewer problems were solved. However, in this experiment, this effect was also present for false memories. Of course, in our second experiment, we looked at the consequences of NBMs by looking at reaction times, while in the study by Wang and colleagues, the consequences of NBMs were examined by focusing on solution rates. Still, our results and the results by Wang and colleagues do show that belief seems to play an important role in guiding behavior but more studies using different paradigms are necessary.

Although speculative, in our opinion, there are two possible explanations for our findings concerning the consequences of nonbelieved true memories. First, the result that slower identifications were observed for both nonbelieved true memories and believed, not-remembered true items suggests that for true memories, belief *and* recollection both play a major role in guiding behavior. What this suggests is that at least for tasks as our PCT, having both a belief and a recollection determine whether you can successfully (i.e., quickly) complete the task. When belief or recollection is undermined, this adversely affects performance. Indeed, the idea that belief and recollection are relevant can be seen from the finding that true memories were identified more rapidly than when belief or recollection was absent. Of course, there is also an alternative possibility. Perhaps presenting participants with feedback about their authentic recollections confuses participants and this negatively impacts their representation of items (e.g., words). This confusion about their own representations might make them slower in their identification for both nonbelieved memories and believed, not-remembered items. Although possible, the idea that feedback causes confusion regarding participants' representations across the board (i.e., for belief and recollection) is unlikely, as we did not find such a general effect for false memory.

Our finding that undermining belief has different consequences for true and false memories begs the question about the possible reasons for this divergent pattern. One option is to relate our finding to how recent work has viewed the adaptive function of true and false memory (e.g., Howe, 2011; Nairne & Pandeirada, 2008; Otgaar & Howe, 2014; Schacter, Guerin, & St. Jacques, 2011). According to this line of work, memory evolved to process information relevant for survival purposes and to simulate future events that might improve prospective decision-making. This flexibility in imaginative processes foments the production of false memory and so, according to this interpretation, false memories might be regarded as simple by-products of a flexible memory system.

However, this work has also revealed that false memories often exert positive and adaptive functions. For example, there is documentation showing that false memories are linked to creativity (Dewhurst, Thorley, Hammond, & Ormerod, 2011). Other work has revealed that counterfactual thinking (i.e., mental simulations of alternative outcomes to past experiences), which is regarded as an adaptive construct, is closely connected with the formation of false memories (Gerlach, Dornblasser, & Schacter, 2013). Finally, studies have shown that false memories frequently serve as better primes on problem-solving tasks than true memories (e.g., Howe, Threadgold et al., 2013; Howe et al., in press; Otgaar et al., 2015). These findings suggest that false memories are not simple by-products and can have consequences in many different areas.

One likely candidate for why true and false memories behave differently when belief is undermined is because false memories are self-generated and true memories are other-generated

(Howe et al., in press). That is, false memories that are elicited in the DRM paradigm are the result of internal processes such as imagination, source monitoring, and associative activation, whereas true memories are the result of external input (e.g., experiencing an event) that needs to be encoded and consolidated. Processes such as source monitoring and associative activation are mechanisms purely related to recollection and hence, are likely to put more weight on recollection relative to belief (e.g., Collins & Loftus, 1975; Johnson, Hastroudi, & Lindsay, 1993). The implication is that for false memories to have any consequence on behavior, recollection must be more relevant than belief. So, if participants' memories are challenged leading to nonbelieved false memories, the recollective part of the memory is driving faster reaction times. Interestingly, belief is often linked to concepts such as confidence (Otgaar et al., 2016). False memories are often expressed with high confidence (e.g., Gallo & Roediger, 2002). One interesting but as yet not studied issue is whether nonbelieved false memories in the DRM paradigm are characterized by low confidence. If true, this would imply that false memories with low confidence could be better primes in tasks such as the perceptual closure task than false memories with high confidence. True memories are formed by a diverse set of external output such as social influences and thus, belief and recollection are both important in guiding behavior. Indeed, for some authors (Nelson, 1993; Nelson & Fivush, 2004), the function of (autobiographical) memory is a social one. This view stipulates that the functional significance of (autobiographical) memory is to share memories with each other leading to a better retention of memories. For such a function to work properly, it is of course important to have both strong beliefs and recollections in the occurrence of events before sharing (or deciding to share) memories with others.

As subsidiary aims, we conducted some exploratory analyses. We did not find that the emotional aspect of stimuli affected NBM rates or the performance on the PCT. Although this might be seen in contrast with the finding from Mazzoni et al. (2010) that NBMs received higher negative emotion ratings than other types of memories, our experiments did not target the kind of memories (i.e., autobiographical) that Mazzoni and colleagues tested (see also below). Our results also did not find any support for any individual differences that might catalyze NBM rates. Of course, this is one of the first studies to examine such individual differences so future research should attempt to examine whether this could be replicated. Finally, as in previous studies (e.g., Clark et al., 2012; Mazzoni et al., 2010; Otgaar et al., 2013), NBMs often did not differ from believed memories (true memories) in terms of phenomenology supporting the idea that NBMs feel “memory-like”.

It is important to stress that our findings might be due to alternative explanations. One explanation that has also received previous empirical attention is that an intervening memory test (e.g., recognition task) might affect the formation of true and false memory in different ways and that this affects the performance on the PCT. However, as already noted, previous experiments have revealed (e.g., Howe et al., 2011; Otgaar et al., 2015) that when no memory test was included before the final task (e.g., PCT, CRAT), a similar pattern emerged in that false memories served as better primes than true memories. Furthermore, one may posit that our divergent pattern in true and false memories emerged because the critical lures are items that are most associated to the presented items thereby leading to faster identifications. However, in previous work, we have replaced critical lures with presented items and we again found that false memories served as the best primes (Otgaar et al., 2015). One might also posit that our findings are driven by demand effects. Although such an explanation cannot be completely ruled out, this interpretation is difficult to reconcile with our finding that certain memory types have *differential* behavioral consequences. If demand effects are relevant, then one might expect that there would be no differences between different memory types in terms of PCT performance.

Of course, our results should be interpreted with caution because of the following. First, in the current experiments, we used the DRM paradigm to elicit true and false memories. Although some studies show that (false) memories elicited by this paradigm are linked to autobiographical memory (e.g., Gallo, 2010; Otgaar, Verschuere, Meijer, & van Oorsouw, 2012), there is also evidence showing no link (e.g., Ost et al., 2013; see also Wade et al., 2007). As a consequence, our ideas should be further tested using other procedures to elicit nonbelieved true and false memories (e.g., imagination inflation). Second, in the present experiments, we used the performance of the PCT as a proxy for behavior. One might argue that this type of behavior is a far stretch from the type of behavior on which we base our decisions in daily life. So, at the minimum, future experiments should attempt to use other tasks measuring other types of behavior and examine whether our findings can be replicated in such tasks as well. Finally, although our focus was on the effects of nonbelieved memories on the PCT task, when looking at other memory types, we did not succeed in obtaining many believed, not-remembered items (see Footnote 2). The result is that the PCT data analysis for these items should be regarded as exploratory. So, future studies using this procedure should test more participants in order to get a sufficient number of all the different memory types.

Nonetheless, besides these limitations, the present experiments demonstrate hitherto two unreported results. First, we have identified a new way to successfully elicit nonbelieved memories by resorting to the DRM paradigm. Second, when belief is undermined, nonbelieved false memories lead to faster identifications on the PCT while nonbelieved true memories were identified much more slowly. Our experiments suggest that our behavior is adversely affected when belief is undermined for true memories and is strengthened when belief is surrendered for false memories. Hence, the current experiments indicate that in order to truly examine the consequences of belief and recollection, true and false memories should be studied simultaneously.

References

Bernstein D.M., Laney, C., Morris, E.K., & Loftus, E.F. (2005). False memories about food can produce food avoidance. *Social Cognition, 23,* 11–34.

Bernstein, D.M., & Loftus, E.F. (2009). The consequences of false memories for food preferences and choices. *Perspectives on Psychological Science, 4,* 135-139.

Bernstein, D.M., Pernat, N., & Loftus, E.F. (2011). The false memory diet: False memories alter food preference. In: Preedy VR, Watson RR, Martin CR, editors. *Handbook of behavior, food, and nutrition.* New York: Springer, 1645–1663.

Bernstein, E.M., & Putnam, E.W. (1986). Development, reliability, and validity of a dissociation scale. *Journal of Nervous and Mental Disease*, *174*, 727–734.

Bernstein, D., Scoboria, A. & Arnold, R. (2015). Suggestion affects the formation and then the consequences of false memory. *Acta Psychologica*, *156*, 1-7.

Bluck, S. (2015). Going global: Functions of autobiographical remembering world tour. *Memory, 23*, 111-118.

Brainerd, C.J. (2013). Murder must memorise. *Memory, 21*, 547-555.

Brainerd, C.J., Reyna, V.F., & Ceci, S.J. (2008). Developmental reversals in false memory: A review of data and theory. *Psychological Bulletin, 134*, 343–382.

Clark, A., Nash, R. A., Fincham, G., & Mazzoni, G. (2012). Creating non-believed memories for recent autobiographical events. *PLOS: One, 7,* 1-7.

Cnaan, A., Laird, N. M., & Slasor, P. (1997). Using the general linear mixed model to analyse unbalanced repeated measures and longitudinal data. *Statistics in Medicine, 16*, 2349 2380.

Collins, A. M., & Loftus, E. F. (1975). A spreading activation theory of semantic processing. *Psychological Review*, *82*, 407-428.

Crowne, D. P., & Marlowe, D. (1960). A new scale of social desirability independent of psychopathology. *Journal of Consulting Psychology*, *24*, 349-354.

Deese, J. (1959). On the prediction of occurrence of particular verbal intrusions in immediate recall. *Journal of Experimental Psychology*, *58*, 17–22.

Dewhurst, S. A., Thorley, C., Hammond, E. R. & Ormerod, T. C. (2011) Convergent, but not divergent, thinking predicts susceptibility to associative memory illusions. *Personality and Individual Differences*, 51, 73-76.

Freng, S., & Kehn, A. (2013). Determining true and false witnessed events: Can an eyewitness-implicit association test distinguish between the seen and unseen? *Psychiatry, Psychology and Law, 20*, 761-780.

Gallo, D. A. (2010). False memories and fantastic beliefs: 15 years of the DRM illusion. *Memory & Cognition*, *37*, 833- 848.

Gallo, D.A., & Roediger, H.L. (2002). Variability among word lists in eliciting memory illusions: evidence for associative activation and monitoring. *Journal of Memory and Language*, *47*, 469-497.

Geraerts, E., Bernstein, D. M., Merckelbach, H., Linders, C., Raymaekers, L., & Loftus, E. F. (2008). Lasting false beliefs and their behavioral consequences. *Psychological Science*, *19*, 749– 753.

Gerlach, K. D., Dornblaser, D. W., & Schacter, D. L. (2013). Adaptive constructive processes and memory accuracy: Consequences of counterfactual simulations in young and older adults. *Memory*, *22*, 145-162.

Goff, L.M., & Roediger, H.L. (1998). Imagination inflation for action events: Repeated imaginings lead to illusory recollections. *Memory & Cognition, 26*, 20-33.

Gudjonsson, G. H. (1989). Compliance in an interrogation situation: A new scale. *Personality and Individual Differences,* 10, 535– 540

Gudjonsson, G. H. (1997). *The Gudjonsson Suggestibility Scales Manual*. Hove, UK: Psychology Press.

Gudjonsson, G. H., & Sigurdsson, J. F. (2003). The relationship of compliance with coping strategies and self-esteem. *European Journal of Psychological Assessment*, 19, 117-123.

Hart, R. E., & Schooler, J. W. (2006). Increasing belief in the experience of an invasive procedure that never happened: the role of plausibility and schematicity. *Applied Cognitive Psychology*, *20*, 661–669.

Howe, M. L. (2011). The adaptive nature of memory and its illusions. *Current Directions in Psychological Science*, *20*, 312-315.

Howe, M. L., Garner, S. R., Charlesworth, M., & Knott, L. (2011). A brighter side to memory illusions: False memories prime children's and adults' insight-based problem solving. *Journal of Experimental Child Psychology*, *108*, 383-393.

Howe, M. L., Garner, S. R., & Patel, M. (2013). The positive consequences of false memories. *Behavioral Sciences and the Law*.

Howe, M. L., Garner, S. R., Threadgold, E., & Ball, L. J. (2015). Priming analogical reasoning with false memories. *Memory & Cognition*, *43*, 879-895.

Howe, M. L., Threadgold, E., Norbury, J., Garner, S., & Ball, L. J. (2013). Priming children's and adults' analogical problem solutions with true and false memories.. *Journal of Experimental Child Psychology, 116*, 96-103.

Johnson, M.K., Foley, M.A., Suengas, A.G., & Raye, C.L. (1988). Phenomenal characteristics of memories for perceived and imagined autobiographical events. *Journal of Experimental Psychology: General, 117*, 371-376.

Johnson, M.K., Hashtroudi, S., & Lindsay, D.S. (1993). Source monitoring. *Psychological Bulletin*, *114*, 3–28.

Levitis, D., Lidicker, W., & Freund, G. (2009). Behavioural biologists do not agree on what constitutes behaviour. *Animal Behaviour*, *78*, 103-110.

Luteijn, F, & Barelds, D.P.H. (2014). *GIT2 Groninger Intelligentie Test 2. Handleiding*. Amsterdam: Harcourt test Publishers.

Marini, M., Agosta, S., Mazzoni, G., Dalla Barba, G., & Sartori, G. (2012). True and false DRM memories: Differences detected with an implicit task. *Frontiers in Psychology, 3*, 1-7.

Mazzoni, G.A.L, Clark, A., & Nash, R.A. (2014). Disowned recollections: Denying true experiences undermines belief in occurrence but not judgments of remembering. *Acta Psychologica*, *145*, 139-146.

Mazzoni, G. & Kirsch, I. (2002). Autobiographical memories and beliefs: a preliminary metacognitive model. In T. Perfect, B. Schwartz (Eds.) *Applied Metacognition* (pp. 121-145). Cambridge, U.K., Cambridge University Press.

Mazzoni, G., Loftus, E.F., & Kirsch, I. (2001). Changing beliefs about implausible autobiographical events: A little plausibility goes a long way. *Journal of Experimental Psychology: Applied*, *7*, 51-59.

Mazzoni, G., Loftus, E. F., Seitz, A., & Lynn, S.J. (1999). Changing beliefs and memories through dream interpretation. *Applied Cognitive Psychology*, *13*, 125-144.

Mazzoni, G., & Scoboria, A., & Harvey, L. (2010). Non-believed memories. *Psychological Science, 21*, 1334-1340.

Nairne, J. S., & Pandeirada, J. N. S. (2008). Adaptive memory: Remembering with a stone-age brain. *Current Directions in Psychological Science, 17*, 239-243.

Nash, R., Wheeler, R. L. & Hope, L. (2015). On the persuadability of memory: Is changing people's memories no more than changing their minds? *British Journal of Psychology, 106*, 308-326.

Nelson, K. (1993). The psychological and social origins of autobiographical memory. *Psychological Science, 4*, 1- 8

Nelson, K., & Fivush, R. (2004). The emergence of autobiographical memory: A social cultural developmental theory. *Psychological Review, 2*, 486- 511.

Okado, Y., & Stark, C.E.L. (2003). Neural processing associated with true and false memory retrieval. *Cognitive, Affective, and Behavioral Neuroscience*, *3*, 323-334.

Ost, J, Blank, H., Davies, J., Jones, G., Lambert, K., & Salmon, K. (2013). False memory ≠ false memory: DRM errors are unrelated to the misinformation effect. *PLoS One, 8.*

Otgaar, H., Candel, I., Memon, A., & Almerigogna, J. (2010). Differentiating between children's true and false memories using Reality Monitoring criteria. *Psychology, Crime & Law, 16*, 555-566.

Otgaar, H., & Howe, M.L. (2014). What kind of memory has evolution wrought? *Memory, 22*, 1- 8.

Otgaar, H., Howe, M.L., Clark, A., Wang, J., & Merckelbach, H. (2015). What if you went to the police and accused your uncle of abuse? Misunderstanding concerning the benefits of memory distortion: A commentary on Fernandez (2015). *Consciousness and*

Cognition, 33, 286-290.

Otgaar, H., Howe, M.L., Memon, A., & Wang, J. (2014). The development of differential mnemonic effects of false denials and forced confabulations. *Behavioral Sciences and the Law, 32*, 718-731.

Otgaar, H., Meijer, E.H., Giesbrecht, T., Smeets, T., Candel, I., & Merckelbach, H. (2010). Children's suggestion-induced omission errors are not caused by memory erasure. *Consciousness and Cognition, 19,* 265-269.

Otgaar, H., Peters, M., & Howe, M.L. (2012). Dividing attention lowers children's but increases adults' false memories . *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38,* 204-210.

Otgaar, H., Scoboria, A., & Mazzoni, G. (2014). On the existence and implications of nonbelieved memories. *Current Directions in Psychological Science, 23,* 349-354.

Otgaar, H., Scoboria, A., Howe, M.L., Moldoveanu, G., & Smeets, T. (2016). Challenging memories in children and adults using an imagination inflation procedure. *Psychology of Consciousness: Theory, Research, and Practice, 3,* 270-283.

Otgaar, H., Scoboria, A., & Smeets, T. (2013). Experimentally evoking nonbelieved memories for childhood events. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 39,* 717-730.

Otgaar, H., Verschuere, B,. Meijer, E., & van Oorsouw, K. (2012). Children's implanted false memories originate from memory traces, not compliance. *Acta Psychologica, 139,* 397-403.

Pezdek, K., Blandon-Gitlin, I., & Gabbay, P. (2006). Imagination and memory: Does imagining events lead to false autobiographical memories? *Psychonomic Bulletin and Review*, *13*, 764–769.

Pezdek, K., Finger, K., & Hodge, D. (1997). Planting false childhood memories: The role of event plausibility. *Psychological Science*, *8*, 437–441.

Piaget, J. (1951). *Play, dreams, and imitation in childhood* (L. Gattegno & F.M. Hodsen, Trans.). New York: Norton.

Ratcliff, R. (1993). Methods for dealing with reaction time outliers. *Psychological Bulletin*, *114*, 510-532.

Roediger, H. L., III, Watson, J. M., McDermott, K. B., & Gallo, D. A. (2001). Factors that determine false recall: A multiple regression analysis. *Psychonomic Bulletin & Review*, *8*, 385- 407.

Roediger, H.L., & McDermott, K.B. (1995). Creating false memories: remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *21*, 803–14.

Rubin, D. C. (2006). The basic-systems model of episodic memory. *Perspectives on Psychological Science, 1*, 277-311.

Scoboria, A., Boucher, C., & Mazzoni, G. (2015). Reasons for withdrawing belief in vivid autobiographical memories. *Memory*, *23*, 545-562.

Schacter, D.L., Guerin, S.A., & St. Jacques, P.L. (2011). Memory distortion: An adaptive perspective. *Trends in Cognitive Sciences, 15*, 467-474.

Scoboria, A., Jackson, D., Talarico, J., Hanczakowski, M., Wysman, L., & Mazzoni, G. (2014). The role of belief in occurrence within autobiographical memory. *Journal of*

Experimental Psychology: General, 143, 1242-1258.

Scoboria, A., Mazzoni, G., & Jarry, J. (2008). Suggesting childhood food illness results in reduced eating behavior. *Acta Psychologica, 128*, 304-309.

Scoboria, A., Mazzoni, G., Jarry, J., & Bernstein, D. (2012). Personalized and not general suggestion produces false autobiographical memories and suggestion-consistent behavior. *Acta Psychologica, 139,* 225-232.

Scoboria, A., Mazzoni, G., Kirsch, I. & Relyea, M. (2004). Plausibility and belief in autobiographical memory. *Applied Cognitive Psychology, 18,* 791-807.

Scoboria, A., & Talarico, J.M. (2013). Indirect cueing elicits distinct types of autobiographical event representations. *Consciousness and Cognition, 22*, 1495-1509.

Scoboria, A., Wysman, L., & Otgaar, H. (2012). Credible suggestions affect false autobiographical beliefs. *Memory, 5,* 429-442.

Sharman, S.J. & Scoboria, A. (2009). Imagination affects perceived plausibility, but plausibility does not affect imagination inflation. *Applied Cognitive Psychology, 23,* 813-827.

Van Ginkel, J. R., & Van der Ark, L. A. (2005). SPSS syntax for missing value imputation in test and questionnaire data. *Applied Psychological Measurement*, *29*, 152-153.

Volbert, R., & Steller, M. (2014). Is this testimony truthful, fabricated, or based on false memory? Credibility assessment 25 years after Steller and Kohnken (1989). *European Psychologist, 19,* 207-220.

Wade, K. A., Sharman, S. J., Garry, M., Memon, A., Mazzoni, G., Merckelbach, H., & Loftus, E. F. (2007). False claims about false memory research. *Consciousness & Cognition,16*, 18-28.

Wang, J., Otgaar, H., Howe, M.L., Smeets, T., Merckelbach, H., & Nahouli, Z. (in press).

Undermining belief in false memories leads to less efficient problem-solving behavior. *Memory*.

West, B., Welch, K. B., & Galecki, A. T. (2007). *Linear mixed models a practical guide using statistical software*. CRC: Chapman & Hall.

Footnote

[1] The participant with no true memories indicated on the memory and belief ratings to have nonbelieved true memories. The reason for this is unclear and similar effects were obtained when the participant was dropped from the analyses

[2] The PCT analyses were performed on 51 participants. The imputation analyses made sure that all memory types had an equal amount of data contain mean reaction times. Without the imputation of data, the distribution and number of mean reaction time data per memory type was unequal and as follows: true memory (n = 49), false memory (n = 39), nonbelieved true memory (n = 20), nonbelieved false memory (n = 16), believed, not-remembered true (n = 8), believed, not-remembered false (n = 9)

[3] We conducted Pearson's correlations between the scores on the DES, GCS, MC-SDS and the number of different memory types (true/false memory; nonbelieved true/false memory; believed, not-remembered true/false). No statistically significant correlations emerged.

Table 1. *Percentages of different memory types (BNR = believed, not-remembered) after the challenge*

	True memory	False memory	Nonbelieved true	Nonbelieved false	BNR true	BNR false
Percentages (number)	48.95% (*n*=163)	21.02% (*n*=70)	7.2% (*n*=24)	2.7% (*n*=9)	1.8% (*n*=6)	0.3% (*n*=1)

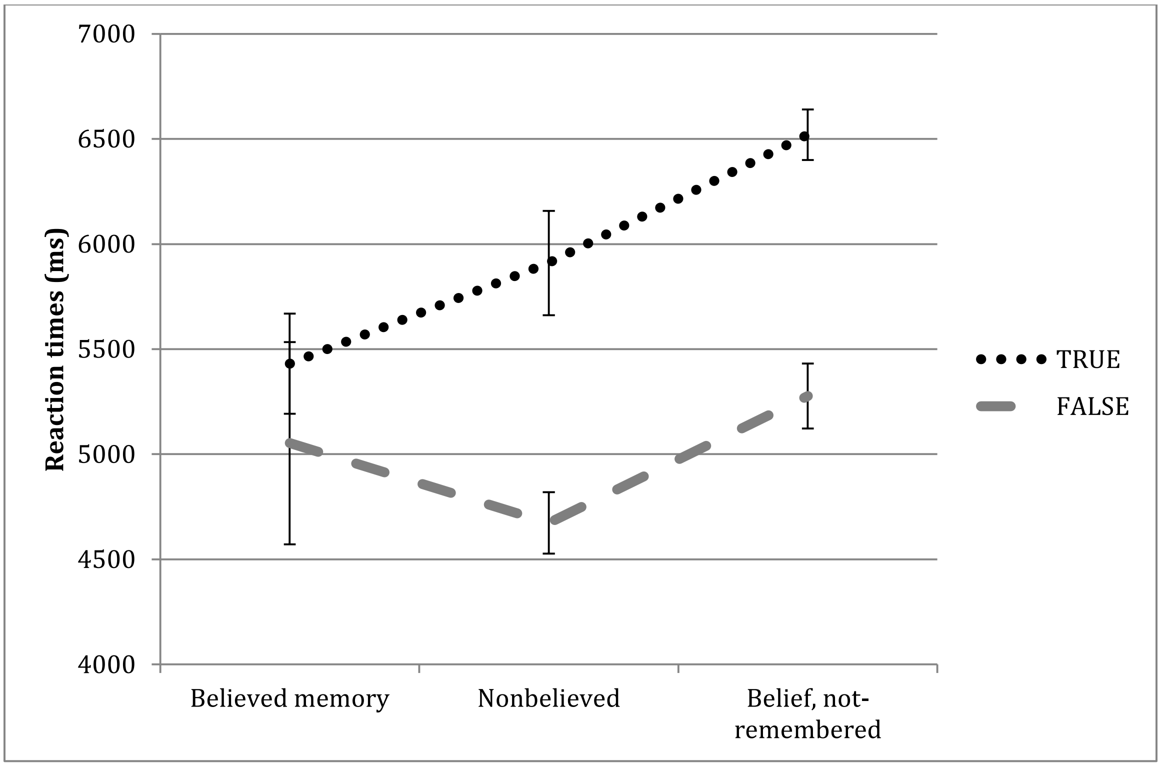
Table 2. *Percentages of different memory types (BNR = believed, not-remembered) after the challenge*

	True memory	False memory	Nonbelieved true	Nonbelieved false	BNR true	BNR false
Percentages (number)	55.42% (*n*=363)	17.86% (*n*=117)	8.2% (*n*=54)	4.9% (*n*=32)	2.0% (*n*=13)	2.4% (*n*=16)

Figure Caption

Figure 1. Perceptual closure task performance of different memory types (error bars represent confidence intervals)

Figure 1


7000
6500
6000
5500
5000
4500
4000
Reaction times (ms)
Believed memory
Nonbelieved
Belief, not-
remembered
TRUE
FALSE