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False denials increase false memories for trauma-related discussions

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ABSTRACT

False denials are sometimes used to cope with traumatic experiences. We examined whether false denials can affect true and false memory production for a traumatic event and conversations surrounding the trauma. One hundred and twenty-six participants watched a trauma analogue video of a car crash before being randomly asked in a discussion with the experimenter to (1) respond honestly or (2) falsely deny that certain details happened in the video. After one week, all participants received misinformation about the discussion with the experimenter and the car crash. Finally, all participants were instructed to respond truthfully in a source memory task. Participants who falsely denied information during the first session were statistically significantly more prone than honest participants to omit details they denied and to report misinformation about what was discussed in the first session. Our work suggests that false denials of a traumatic experience might lead to both forgetting and increased false memory levels for earlier conversations about the event.

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Trauma film paradigm; false memory; false denial; lying; denial-induced forgetting

There are different ways to cope with traumatic experiences such as sexual abuse. For example, some people may tend to discuss traumatic incidents with someone else, while others tend to cope with psychological trauma by not thinking about it, or even denying that it happened when asked (Bain et al., 2015; Carver et al., 1989; Walsh et al., 2010). Leander (2010) investigated reports of 27 children who had been sexually abused to assess whether these children reported or denied their traumatic experiences. Importantly, these involved cases in which certain details concerning abuse could be verified by external evidence such as pictures or videos. In total, the 27 children explicitly denied having experienced documented abusive acts on 95 occasions in the first interview that the police conducted with them. Cases like these shed light on the fact that sometimes people falsely deny traumatic experiences (Lyon, 2007).

Reluctant victims or eyewitnesses do sometimes come forward with the truth in later interviews, and their testimony might then be used as evidence in court (Blasbalg et al., 2021). In such cases, it is not uncommon that testimony is not just given about the (traumatic) events, but also regarding previous conversations with parents, caretakers, or the police (Lawson & London, 2015, 2017; Stolzenberg & Lyon, 2014; Wu et al., 2021). The latter is

called *conversational testimony* and its reliability is severely understudied, being labelled as the “orphan child of witness memory researchers” (p. 3, Davis & Friedman, 2007). The problem with such conversational testimony is that victims who disclose a traumatic event after initial denial might be faced with suggestive interviewing tactics, including false post-event information (Lamb et al., 2002). For example, child victims sometimes disclose their abusive experiences with parents and research shows that parents frequently ask highly suggestive questions during such conversations (Korkman et al., 2014). The question that arises is whether earlier attempts of false denials might affect memory and memory errors after exposure to suggestive, potentially misleading information concerning the experienced, traumatic event and previous conversations surrounding it.

Memory effects following false denials

False denials and forgetting

One research line has found that false denials might lead to omission errors in witness statements (Otgaar & Baker, 2018). In one of the first studies on the memory effects of false denials, Otgaar et al. (2014) asked children (6–8

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and 10–12 year-olds) and adults to watch a video. In the following step, the experimenter asked the participants questions about the video in an interview. Some participants were asked to falsely deny that they had seen several details in this video, whereas a control group was asked to respond honestly. After a one-week delay, participants' memory for both the interview and video was tested in a source memory test. Otgaar et al. (2014) found that participants who falsely denied details of the video were more likely than honest control participants to forget details they had discussed in the interview. Memory for the video itself was not undermined by false denial. This effect, in which false denials led to forgetting of details that were *discussed* in previous conversations with the experimenter, has since been called *denial-induced forgetting* (Otgaar et al., 2016).

Denial-induced forgetting has been replicated using different types of stimuli (e.g., Otgaar et al., 2016, 2018; Romeo et al., 2019; but see also Li et al., 2022). Specifically, using a trauma analogue virtual reality scene of a plane crash, Romeo et al. (2019) did not only replicate denial-induced forgetting for conversations about a trauma analogue stimulus, but also found that false denials led to forgetting of the traumatic event itself. At present, it is unclear whether false denials might only negatively affect memory for the experienced event when this event is traumatic in nature (Romeo et al., 2019). This is because research using more neutral stimuli has not consistently found that false denials lead to forgetting of details of the stimulus itself, but have predominantly replicated forgetting of previous conversations after denial (e.g., Battista et al., 2020; Otgaar et al., 2014, 2016, 2018). Overall, this research shows that false denials might lead to omission errors regarding previous conversations.

Even though the exact mechanisms behind the memory effects of false denials are unclear, several potential ones have been proposed. For example, Otgaar et al. (2020) have suggested that perhaps the forgetting effects of false denials are driven by inhibition processes when someone attempts to retrieve a memory. Specifically, someone who is falsely denying certain details might try not to think about the events they are lying about. Such attempts not to think about an event have been linked to retrieval inhibition in related forgetting paradigms (Otgaar & Baker, 2018; see also Anderson & Green, 2001; Anderson & Hulbert, 2021). If this is indeed what happens in people who falsely deny, then (falsely) denying certain items might render them less accessible when the person later attempts to recollect them.

Another possible mechanism behind the memory effects of false denials relates to the amount of cognitive resources employed during a false denial. False denials generally can be considered a lying strategy, and lying has been tied to different memory outcomes (Otgaar & Baker, 2018). According to the memory and deception framework (Otgaar & Baker, 2018), these depend on the cognitive resources required to carry out a specific lying

strategy. Strategies which take up lower amounts of cognitive resources are related to omission errors, according to this framework, whereas ones that take up higher amounts of cognitive resources would be related to commission errors. Such commission errors occur when someone falsely reports a detail that was never actually presented or experienced and are also called false memories (Loftus, 2005). In line with this framework, Battista et al. (2020, 2021) argued that whether false denials lead to omission or commission errors is tied to the amount of cognitive resources required when executing a denial. Indeed, they built on the memory and deception framework (Otgaar & Baker, 2018) arguing that false denials which require a smaller amount of cognitive resources are tied to forgetting, but that complex false denials requiring many cognitive resources could additionally lead to commission errors and thus false memories (or false reporting).

False denials and false memories

In court cases, false memories and false memory reports can occur for instance when the police resort to suggestive questioning. The latter might sometimes be used to facilitate disclosure when the police is faced with a denying victim (Lamb et al., 2002). Moreover, during interviews with alleged victims, police officers might ask suggestive questions about previous disclosures and conversations surrounding the event (Stolzenberg & Lyon, 2014). Witnesses may also encounter testimonies containing false details from other eyewitnesses (Wright et al., 2009). This type of misleading information – called *misinformation* – may lead to the creation of false reports, and even entire false memories (Loftus, 2005).

A voluminous body of research has studied the effects of misleading information on false memory formation using the misinformation paradigm (Loftus, 2005). This paradigm follows a three-step procedure: First, participants are presented with a stimulus such as a video of a mock crime. Second, participants receive misinformation (e.g., “In which hand did the robber hold the gun?”, when in fact no gun was present). Third, participants' memory for the stimulus is tested. The misinformation effect describes the finding that participants who have received misinformation report this in their later memory reports, and these false memory reports could be a sign that suggestion-based false memories were formed (see Loftus et al., 2005 for a review).

While the possible connection between false denials and suggestion-based false memories is severely understudied, some related research (e.g., Bain et al., 2015; Howard & Hong, 2002) exists that supports the notion that false denials might lead to increased susceptibility to suggestion. Specifically, these studies have examined the relationship between emotion-focused coping mechanisms (e.g., denial) and suggestibility. Emotion-focused coping strategies are strategies aimed at avoiding stressful

situations and include venting emotions, denial, or alcohol abuse (Howard & Hong, 2002). Howard and Hong (2002) investigated the relationship between different coping strategies and suggestibility by asking participants to fill out a self-report questionnaire (i.e., COPE) that assesses a person's typical coping style and conducting the Gudjonsson Suggestibility Scale 2 (GSS2) with them. The GSS2 yields several different suggestibility scores, one of which is related to misinformation endorsement. Participants who reported using more emotion-focused coping strategies also reported more misinformation compared to participants who reported using more problem-focused coping strategies. These results were replicated by Bain et al. (2015) who likewise found that emotion-focused coping increased vulnerability to misinformation.

The authors of both studies tie these findings to a model by Gudjonsson and Clark (1986) on interrogative suggestibility (Bain et al., 2015; Howard & Hong, 2002). Bain et al. (2015) argued that emotional-avoidant coping strategies might divert cognitive resources away from the task of accurately recalling information, and towards managing emotions. Thereby, according to the authors, the task of detecting discrepancies between the original events and misinformation is rendered more difficult, so that misinformation is more frequently reported when someone employs an emotion-focused coping strategy.

While this research line is related to the question of how false denials might affect reports of suggestion-based false memories, it does not *directly* answer this question. In research on emotion-coping and susceptibility to suggestion, false denials were studied as part of the general umbrella coping construct of emotion-focused coping since that was the aim of the researchers (Howard & Hong, 2002). To understand the independent impact of false denials on suggestion-based false memory formation, studies must focus on denials alone. Moreover, participants in these studies (Bain et al., 2015; Howard & Hong, 2002) did not actively employ any strategies during the experiment. This is because the aim of these studies was to investigate individuals' typical coping styles. Participants in the current experiment will actively employ false denials.

Theoretical framework

There are several memory theories that may help us to understand how false denials could be tied to (reporting of) false memories. There is currently not one dominant theory in the field of false memory formation. Instead, different theories exist, and they are all supported by some current literature (e.g., Bialer et al., 2021; Brainerd & Reyna, 2019; Brackmann et al., 2019; Bücken et al., 2022; Gamliel & Kreiner, 2020; Jalbert et al., 2021; Oliveira et al., 2019; Otgaar et al., 2019; Wang et al., 2019). The first is associative activation theory (i.e., AAT; Howe et al., 2009; Otgaar et al., 2019) which holds that our memory works as a network system of interrelated knowledge

nodes (e.g., "banana", "ripe", "citrus"). According to this theory, activation can spread through this interconnected network when we encode information, and nodes that are associatively related but not actually part of the experience that is being encoded can be activated as well. When this happens, the activated node might become erroneously part of the experience, and later be retrieved as such, leading to a false memory.

Second, the discrepancy detection principle (Tousignant et al., 1986) is also useful in understanding the memory effects of false denials. This principle holds that false memories are likely to arise when someone has not noticed that there is a difference – a *discrepancy* – between the originally presented information and some type of false post-event information they might be exposed to, for example during conversations with other people. Thus, they would be more likely to accept that the misinformation is a true account of what happened, and to report this in their own memory reports later on.

Finally, according to fuzzy trace theory (FTT; Brainerd et al., 2008), experiences are encoded into two memory traces: A verbatim trace, storing information related to the specific details of an individual experience (e.g., the colour, shape, size of a chair), and a gist trace, storing information related to the underlying meaning of an experience (e.g., that a chair was present) (Brainerd et al., 2008). Relying on gist traces when retrieval of detailed memories is not possible drives false memory production and increases the likelihood of endorsing misinformation.

What might these theories predict concerning potential effects of false denials on false memories? Looking at AAT on the one hand, and FTT and the Discrepancy Detection Principle on the other leads to two opposing scenarios. The first scenario is that false denials might be tied to a decrease in false memory formation. That is, if false denials inhibit retrieval of information in the memory network, then according to the principles of AAT this inhibition might prevent activation from spreading to related nodes that are not part of the lied about experience itself. If inhibition thus limits spreading activation through the memory network, it would be less likely that "false" associated nodes are accidentally activated, thus decreasing the chance of false memory creation.

The other scenario is that false denials could lead to an increase in suggestion-based false memories. Previous research (Otgaar et al., 2020) shows that false denial might inhibit the retrieval of detailed verbatim information related to the lied about event. In line with the FTT (Brainerd et al., 2008; Brainerd & Reyna, 2002), it can be argued that someone who uses false denials might then have to rely more on gist memory traces. In turn, this would make them more susceptible to reporting false memories. In line with the discrepancy detection principle (Tousignant et al., 1986), someone who uses false denials and thus remembers fewer details might be less likely to detect discrepancies between their experience and other

misleading information. This, in turn, would render it more likely that they produce false memories.

The current experiment

The current experiment examined the effect of false denials on forgetting and the reporting of suggestion-based false memories for a trauma analogue event.¹ Investigating this link between false denials and false memories has both practical and theoretical relevance. The practical relevance is that witnesses and victims who initially falsely deny in interviews might be faced with suggestive information (Lamb et al., 2002), rendering the question of how initial denials may affect suggestibility to false information important when evaluating witness statements in court. From a theoretical perspective, different current false memory theories lead to competing predictions about the possible relation between false denials and false memory reports. As such, investigating this question will add to scientific progress in the field (Kuhn, 1962; Popper, 1959).

Specifically, in the current experiment, a trauma analogue video (James et al., 2016; Strange & Takarangi, 2012) was used as the initial stimulus. Half of the participants were asked to repeatedly falsely deny information from this video in an interview with the experimenter, while the other half were asked to respond truthfully. The reason we employed *repeated* false denials was twofold. For one, it is very common for witnesses to be questioned repeatedly (Blasbalg et al., 2021; Fisher et al., 2013). Moreover, repeated false denials have been shown to not only exert stronger mnemonic influences on memory for the interview than single false denials, but have also affected memory for the lied about event in a recent experiment (Battista et al., 2020). Next, participants received misinformation about both the trauma analogue video and the interview, before completing a source memory test.

We expected to find the following. First, we expected that compared with participants in the control condition, those who falsely denied information would remember fewer details pertaining to both the interview *and* the event (Otgaar et al., 2014, 2016, 2018; Romeo et al., 2019). Because previous research that has used a trauma analogue virtual reality scene as the stimulus (Romeo et al., 2019) and repeated false denials (Battista et al., 2020) detected forgetting effects of false denials on event memory, we expected to find the same using a trauma analogue video and repeated denials. Second, we had two competing hypotheses for misinformation endorsement. On the one hand, we hypothesised that participants who falsely denied details would endorse more misinformation about the video and interview as compared with the control group. This hypothesis was based on (1) previous research on coping and suggestibility (e.g., Bain et al., 2015; Bücken et al., 2022; Howard & Hong, 2002) and (2) the discrepancy detection principle

and FTT. Indeed, with the premise that false denials result in poor memory for the interview and stimulus both theories support this hypothesis.

On the other hand, we formulated a competing hypothesis. Specifically, based on AAT (Howe et al., 2009; Otgaar et al., 2019), we hypothesised that false denials might be related to *lower* misinformation endorsement. That is, if the misinformation that participants receive is associatively related to the stimulus and interview, AAT postulates that any retrieval inhibition related to the false denial might also affect misinformation details, making these less accessible during retrieval for participants in the false denial than the honest control group.

Method

Design and participants

The current experiment employed a between-subjects design with condition (2: false denial vs honest control) as the independent variable. All participants received misinformation about both the video and interview and were tested on this once in a final source memory test. There were, therefore, four main dependent variables, calculated from responses to the source memory test: (1) true memory for the interview, (2) true memory for the video, (3) misinformation endorsement for the video (4) and misinformation endorsement for the interview. Based on previous research (Otgaar et al., 2016, 2018; Experiment 1 in Otgaar et al., 2020; Romeo et al., 2019), the mean effect size for studies on false denials using emotional material was large, η^2 (partial) = 0.229. However, to be on the conservative side and to accommodate the mixed results concerning memory effects for the event itself, we anticipated a medium effect size. That is, an a priori power analysis using G*Power (Faul et al., 2007; i.e., test family: t-test, the difference between two independent means, $d = 0.5$, $\alpha = 0.05$, power = 0.80) indicated that a sample of 128 participants was needed. The experiment received ethical approval from the Social and Societal Ethics Committee at KU Leuven (reference number G-2020-2787).

Participants were recruited via the experiment management system of KU Leuven's psychology faculty, through university related Facebook groups, and in-class recruitment. As compensation, participants could either receive partial class credit (only psychology students) or join a raffle for 5 25€ Amazon vouchers. Due to the current COVID-19 situation, the study was completed fully online; the pre-screen took place via a questionnaire on Qualtrics which was shared during recruitment. Following up the pre-screen, participants were contacted via email. The subsequent lab sessions took place via Zoom video calls and lasted around a half an hour each. The current experiment was preregistered on the Open Science Framework (https://osf.io/k3hu7/?view_only=7d68f3f97ac1487d9ed4b61ef935341d) and all data and materials can be

accessed there (https://osf.io/hcunq/?view_only=08769a6c41794a419243f3edab5f3d01).

Prior to scheduling the (online) lab sessions, we used the short form Post-traumatic Stress Disorder (PTSD) Check List – 5 (PCL-5; Zuromski et al., 2019) to screen participants for PTSD symptomatology, a procedure often used in research using trauma analogue stimuli (e.g., Romeo et al., 2019). The short form PCL-5 is a 4-item self-report questionnaire that screens for PTSD symptoms based on the diagnostic criteria of the DSM-5 (B-E; Zuromski et al., 2019). Responses are scored on a 5-point Likert scale, ranging from *Not at all* (0) to *Extremely* (4) and scores can range from 0 to 16. Diagnoses based on this short form PCL-5 have been shown to closely parallel ones obtained with the full PCL-5 (Zuromski et al., 2019). We chose an intermediate (i.e., not liberal or conservative) diagnostic cut-off score and a threshold of a summary score of seven or above. Sensitivity at this threshold is at 89.6%, specificity at 98.5, and the AUC is 0.94 (Zuromski et al., 2019). We excluded participants who scored at or above this threshold to prevent that any specifically vulnerable participants would be exposed to the trauma analogue material. This was done as a preventive measure to ensure no preemptive emotional or psychological problems would be exaggerated by participation in our experiment. Non-eligible participants were debriefed via email. Participants who were eligible to participate were contacted to schedule the online lab sessions.

In total, 213 participants filled out the pre-screening questionnaire ($M_{age} = 23.7$; age range = 17–55). Based on this pre-screening questionnaire, eligibility was determined by (1) age (being above 18) and (2) participants' score on the PCL-5. On average, participants in the pre-screen had a PCL-5 summary score of 4.25, and scores ranged from 0 to 14. Fifty-four participants (25.3%) met the threshold for exclusion based on the PCL-5. Thus, of the 213 participants who completed the pre-screen, only $n = 159$ (74.7%) were eligible to participate in the experiment.

Of the 159 participants who met the eligibility criteria, 129 completed the first online lab session, and $n = 126$ completed both online lab sessions. Our analyses were performed on this sample of 126 participants who completed both sessions. These were on average 22.82 years old ($SD = 5.87$, range = 18–53), predominantly women ($n = 98$, 77.8%), and received compensation either by joining a raffle for five 25€ Amazon vouchers ($n = 47/126$), a class credit ($n = 73/126$), or choosing no compensation ($n = 6/126$).

Materials

Session 1

PANAS. In the current study, the Positive And Negative Affect Schedule (PANAS) was employed as a manipulation check to ensure that our stimulus invoked negative emotions, as is often done in research using the trauma

film paradigm (e.g., Strange & Takarangi, 2012, 2015; Stirling et al., 2021). The PANAS is a brief measure of positive and negative affect that consists of two 10-item mood scales (i.e., a positive and negative subscale) that are rated on a five-point scale from *very slightly or not at all* (1) to *extremely* (5; Watson et al., 1988). The positive subscale includes emotions such as “excited”, “interested” or “proud”, whereas the negative subscale includes emotions such as “scared”, “guilty” and “nervous”. The scales are scored as average scores across the ten items per scale and thus scores can range from 1 to 5. The PANAS can be used as measures of affect for different time periods: *the moment* (PANAS-S), *today, past few days, past few weeks, year, generally* (PANAS-T). For the current study the affective state (at the *moment*), as well as affective trait (*generally*) were measured. The PANAS scales show good internal consistency (Cronbach's $\alpha = 0.89$ for the positive subscale and $\alpha = 0.89$ for the negative subscale for a time instruction to fill the scales out for the *moment*) and are largely uncorrelated ($r = -0.15$ for the instruction to fill the scales out for the *moment*; Watson et al., 1988).

Trauma analogue video. We used a trauma analogue video as our initial stimulus. This specific video has been used in several previous studies on trauma and memory (e.g., Houben et al., 2018; Monds et al., 2013; Strange & Takarangi, 2012). It depicts a car crash caused by an inattentive, texting driver. Three cars crash into each other and there are several fatalities, including a baby. Emergency services arrive on the scene and the video ends with a close-up shot of the driver's face. The video is available at the OSF: <https://osf.io/56rmx/>.

Baseline memory test. All participants completed a *Baseline Memory Test* in order to ensure that the video was sufficiently encoded. This baseline test included three questions about details that were in the video (i.e., true details) and three new details that were not present in the video (i.e., false details) and the questions were rather general Yes/ No type questions (e.g., “Did you see three girls sitting in the car?”). The details included in the baseline memory test were the same for all participants and can be found in Table A1 in the supplementary material in the appendix. “Yes” answers were scored as 1, “No” answers were scored as 0. Scoring for false details was reversed in the analyses to show correct rejections. Thus, possible absolute scores ranged from 0 to 6.

Memory interview task. All participants took part in a structured interview with Yes/ No type questions also called the *Memory Interview Task*. This interview took place on Zoom via video chat. Participants randomly assigned to the false denial condition were instructed to falsely deny in response to all of the questions (e.g., Question: “Did the car drive into the opposite lane?” Answer: “No, the car did not drive into the opposite lane.”). Therefore, they falsely denied all true question details, and correctly denied all false details. Participants in the honest control condition were asked to respond truthfully. The

task contained eight details regarding details that were truly shown in the video (i.e., true items such as “Did you see a stretcher?”) and eight questions about details that were not presented in the video (i.e., false items such as “Was it raining during the accident?”; see Table A2 in the supplementary material appendix). All sixteen questions from the memory interview were asked repeatedly (i.e., three times) so that participants in the denial group would deny all details repeatedly. All participants received the same questions. No items from the baseline memory task were repeated in the memory interview. Items about which misinformation would be given in the second session were not included in the memory interview either to prevent confusion. Since the memory interview task was the manipulation for the current experiment, answers were not scored. The interviewer monitored whether participants followed instructions properly.

Session 2

Misinformation. Participants received misinformation about (1) the interview conversation from the first session and (2) the video. The misinformation of the interview was delivered as part of a summary of the first session. This summary was read to the participants by the experimenter and described the different activities that participants engaged in during the first session. One of these activities was the interview with the experimenter. In this summary of the interview, the experimenter included four points of misinformation by falsely claiming that certain details were discussed in the interview of the previous session. An example for a misinformation detail was “We discussed whether you saw a witness instructing others to call an ambulance”, whereas calling an ambulance was not discussed in the interview. All participants received the same misinformation. Two details of that misinformation pertained to details that were in the video, but not discussed in the interview. The other two were completely new details (see Table A3 for an overview). The latter were, therefore, details that were neither part of the video, nor of the interview.

The misinformation of the video was embedded in an eyewitness account from another witness that was read to participants by the experimenter. Specifically, participants were told that another witness who had seen the car crash from the video had given an account about what happened to the police. Then, they were told that this eyewitness account would be read to them. This eyewitness narrative included some true elements of the crash participants saw during the video, but also introduced several pieces of misinformation. Specifically, the eyewitness narrative was adapted from Houben et al. (2018) and included five points of misinformation. All participants received the same misinformation. The specific misinformation details were the following: “The driver was texting with a boy called John”, whereas the name in the film was “James”; see Table A for details. All of the misinformation details, but none of the true details about the video

which were included in the fake eyewitness account, were used in the source memory test. The misinformation summary and narrative can be found on OSF (https://osf.io/hcunq/?view_only=08769a6c41794a419243f3edab5f3d01).

Source monitoring test. In the second session, participants completed a *Source Monitoring Test*. This memory test was administered as a structured interview, and included 25 details in total (four true details that were in the video and discussed in the interview, four true details that were in the video but not discussed in the interview, four false details that were not in the video but discussed in the interview, four completely new details that were not in the video or interview, five misinformation details from the video misinformation, and four misinformation details from the interview misinformation). No details from the baseline memory test were repeated in the source monitoring test. Participants received two questions for each detail, one pertaining to their memory for the interview (e.g., “Do you remember if we discussed if you saw a helicopter in the interview in the previous session?”) and one pertaining to their memory for the video (e.g., “Do you remember seeing a helicopter in the video?”).

Revised IES. The Revised Impact of Events Scale (IES) was used to measure distress at the end of the second session, one week after exposure to the trauma analogue film. The revised IES consists of 15 items that can be collapsed onto two sub-scales: Seven items converge into the intrusion and eight items into the avoidance subscale (Horowitz et al., 1979). Items include statements such as “I thought about it when I did not mean to.” and are scored on a four-point Likert scale: a score of *not at all* = 0, *rarely* = 1, *sometimes* = 3, *often* = 5 (Joseph, 2000). There are 15 items in total, thus summary scores can range from 0 to 75 (0–35 on the intrusion scale and 0–40 on the avoidance scale). A review of the psychometric properties of the IES showed that it has strong validity and is internally consistent (Intrusions: $M\alpha = 0.86$; Avoidance: $M\alpha = 0.82$; Sundin & Horowitz, 2002). Horowitz (1982) has proposed categories of how scores on the revised IES correspond to levels of clinical concern (i.e., of Post-Traumatic Stress Disorder symptomatology; Joseph, 2000). As a rule of thumb in previous research using the trauma film paradigm, researchers have used an average score of 9–25 on the IES as an indication that the trauma film indeed affected participants, albeit without long-term negative consequences (Strange & Takarangi, 2012; see also Horowitz et al., 1979).

Scoring. Each answer on the Source Monitoring Test was scored with “Yes” responses receiving a value of 1, and “No” responses receiving a value of 0. Thus, one point was assigned for each correctly identified detail discussed in the interview or seen in the video respectively. Further, one point was assigned for each false misinformation detail that was incorrectly identified as having been discussed in the interview or seen in the video. To calculate our four memory indices (i.e., true memory for the video, false memory for the video, true memory for the interview,

and false memory for the interview), we created summary scores. All scores were summed considering (a) items truly presented in the video (maximum score: 10), (b) items truly discussed in the interview (maximum score: 8), (c) items falsely recognised from the video misinformation (maximum score: 5) and (d) items falsely recognised from the interview misinformation (maximum score: 4) – see Table A3 for an overview. For all four memory indices, proportion scores were created by dividing the absolute obtained scores by the maximum scores.

Procedure

Pre-session

See Figure 1 for a diagram of the procedure. Before engaging in the online lab sessions, participants completed a short online pre-screening questionnaire via Qualtrics. This questionnaire asked participants to sign informed consent to the study before participants gave their age and completed the short form PCL-5. Based on their results on this pre-screen, participants were contacted to notify them of their eligibility and to give them either a debriefing (in case of non-eligibility) or to schedule the first lab session (in case of eligibility).

Session one

At the start of the first online video session, participants provided informed consent one more time. Subsequently, they filled out the PANAS-S before and after watching the trauma analogue video. After this, participants completed the baseline memory test, followed by a short distractor task (playing Tetris for five minutes). Next, participants engaged in the memory interview, during which the manipulation occurred so that half of the participants were instructed to falsely deny information about the video, whereas the other half was instructed to respond honestly. Participants were thanked for their participation

in the first half of the experiment and reminded to return one week later for the scheduled second video session.

Session two

After a one week delay ($M = 7.06$ days, $SD = 0.95$), participants returned for the second online video lab session. Framed as a reminder of the previous session, they received a summary of the previous session (including the interview misinformation) as well as a narrative provided by another eyewitness (including misinformation about the video), read to them by the experimenter. Subsequently, as a distractor task, participants completed the PANAS-T questionnaire, before engaging in the Source Monitoring Test where their memory for both the interview conversation of the previous session and the trauma analogue video was tested. Finally, participants completed the revised IES and were debriefed and thanked for their participation.

Data analysis strategy

We used a significance level of $\alpha < 5\%$ for all statistical analyses. For our four main analyses (i.e., on false and true memory for the video and interview respectively), we used Bonferroni corrections to account for multiple testing, meaning that our alpha level was at 1.25% ($5\%/4$). We conducted assumption checks, and for variables that were significantly non-normally distributed and where we found statistically significant results, we additionally report non-parametric (Mann–Whitney U) tests. These were performed to reduce the risk of reporting false positive results caused by skewness, even though our sample was large enough in both experimental groups ($n = 63$ for both) to deal with a deviation from normality. There were no extreme outliers (>3 SD away from the mean) for our memory variables. True and false memory scores are given in proportions.

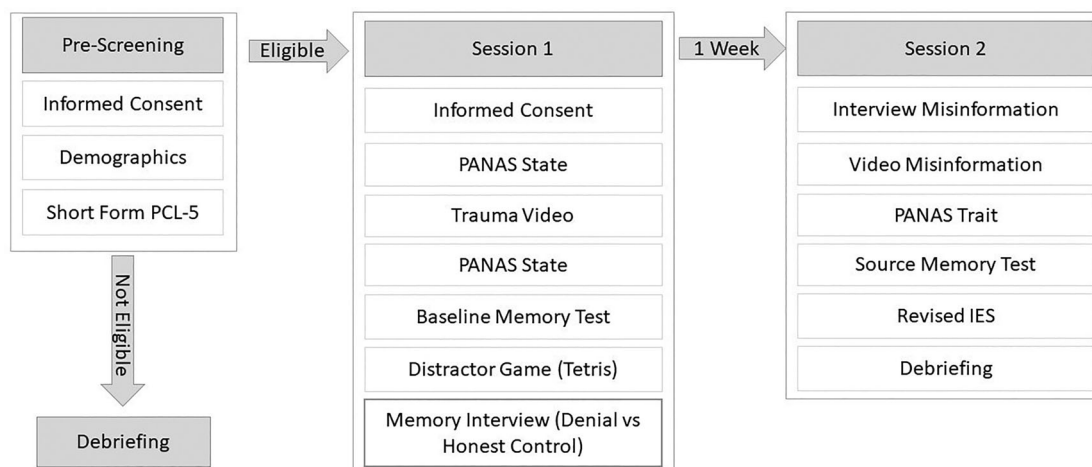


Figure 1. Diagram of the procedure.

Results

PANAS

We conducted paired samples student t-tests to compare participants' PANAS-S scores from the positive and negative subscales pre and post watching the trauma analogue film. Participants had statistically significantly higher scores on the positive PANAS-S subscale *before* being exposed to the film ($M = 3.23$, $SD = 0.5$) than after ($M = 2.55$, $SD = 0.63$), $t(125) = 14.41$, $p < .001$, $d = 1.28$. Moreover, participants had statistically significantly lower scores on the negative PANAS-S subscale *before* being exposed to the trauma analogue stimulus ($M = 1.4$, $SD = 0.38$) than after ($M = 2.09$, $SD = 0.66$), $t(125) = -12.89$, $p < .001$, $d = 1.15$. These results indicate that the trauma analogue film succeeded in affecting participants' emotional states and thereby served as a manipulation check. To ensure that there were no differences in emotionality in participants in the false denial versus honest control condition (and thus to check that our random assignment was effective), we compared participants in the two experimental groups on their positive and negative pre PANAS-S scores using independent samples t-tests. We found no statistically significant differences (positive: $t(124) = -0.41$, $p = 0.68$, $d = 0.07$; negative: $t(124) = -0.53$, $p = 0.6$, $d = 0.1$).

Revised IES

On average, participants scored 5.4 on the Intrusion subscale ($SD = 4.55$) and their intrusion scores ranged from 0 to 20 (of a possible score of 35). On the avoidance subscale participants scored on average a 7.07 ($SD = 6.47$), and their scores ranged from 0 to 25 (of a possible score of 40). On the total score, participants scored on average a 12.47 ($SD = 9.49$) and scores ranged from 0 to 38. According to symptom levels identified by Horowitz (1982) that correspond to scores on the revised IES, and in line with previous research using the trauma film paradigm (e.g., Nahleen, Strange, et al., 2021; Strange & Takarangi, 2012), participants' scores in our sample corresponded to a medium level of clinical symptom concern (i.e., scores ranging from 8.6 to 19).

Baseline memory

On average, participants in the honest control condition correctly classified 5.29 (of 6) details in the baseline memory test ($SD = 0.68$), whereas participants in the false denial condition scored correct on average on 5.21 (of 6) details ($SD = 0.68$). Participants in both conditions correctly recognised on average 2.82 of the three true items from the baseline test, and correctly rejected 2.49 of the three false items on the baseline memory test. Overall, this shows that participants generally encoded the video. There were no statistically significant differences in

baseline memory scores among participants in the two conditions in an independent samples t-test, $t(125) = 0.66$, $p = 0.51$, $d = 0.12$. Because data were skewed, we also performed a non-parametric Mann-Whitney U test, which mirrored the t-test, $W = 2122.5$, $p = 0.46$, $r = 0.07$.

Memory for the interview

True memory

One-tailed independent samples Welch t-tests were performed to compare honest control and false denial participants' proportions of true memory for what was discussed in the interview. Participants in the false denial group remembered statistically significantly fewer details from the interview ($M = 0.82$, $SD = 0.19$) as compared with participants in the honest control condition ($M = 0.94$, $SD = 0.09$), $t(88.28) = 4.52$, $p < 0.001$, $d = 0.81$ (see Figure 2). Due to a non-normal distribution of the data, we additionally performed a non-parametric test. The results of this Mann-Whitney U-test supported the conclusions from the t-test, $W = 2694$, $p = < 0.001$, $r = 0.36$. Moreover, we performed Bayesian analyses and found a Bayes factor of $BF_{10} = 2462.07$. Thus, the estimated Bayes factor suggested that the data were 2462 times more likely to occur under the alternative hypothesis that participants in the false denial group have a lower average true memory score for the interview than honest control participants than under the null hypothesis that there is no difference based on the groups (false denial vs honest control). Of note is also that the interview was generally remembered quite well, as can be seen in the average true memory scores for both groups. Furthermore, as shown in Figure 2, there were two outliers in the false denial group who had especially low true memory scores for the interview.

False memory

We conducted an independent samples t-test to compare the proportion of misinformation details about the interview that participants in the two conditions. There was a

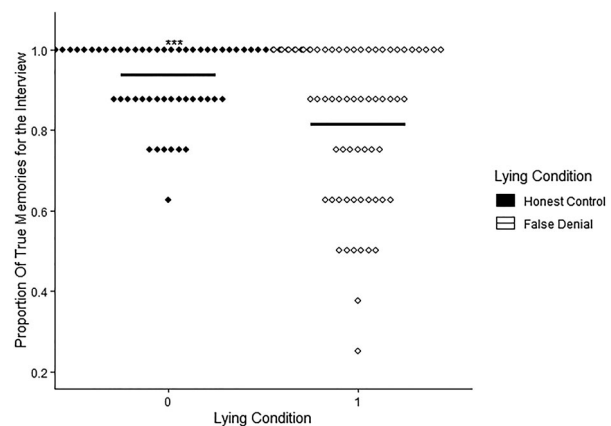


Figure 2. Proportion of true memory for the interview by lying condition. Note: Each dot represents one participant. Means are represented by bars. *** = $p < .001$.

statistically significant difference in false memory levels for the interview between participants in the false denial and honest control groups, $t(125) = -3.42$, $p < 0.001$, $d = 0.61$ (see Figure 3). A non-parametric Mann–Whitney U-test supported these results, $W = 1352$, $p < 0.001$, $r = 0.32$. Specifically, participants in the false denial condition reported more misinformation about the previous interview ($M = 0.41$, $SD = 0.28$) than participants in the honest control condition ($M = 0.25$, $SD = 0.24$). We further performed a Bayesian t-test and found a Bayes factor of $BF_{10} = 32.94$. According to this estimated Bayes factor then, our data were 32.94 times more likely under the alternative hypothesis that the two groups differ in false memory scores than under the null hypothesis.

Memory for the video

True memory

We performed a one-tailed independent samples t-test to compare participants in the honest control and false denial condition on their true memory proportion for the trauma analogue film. We did not find a statistically significant difference between participants in the false denial ($M = 0.58$, $SD = 0.14$) and honest control ($M = 0.57$, $SD = 0.15$) groups, $t(124) = -0.37$, $p = 0.64$, $d = 0.07$. To examine how likely our data would be under the null and alternative hypothesis, we estimated a Bayes Factor ($BF_{01} = 6.81$). This Bayes Factor showed that our data are 6.81 times more likely under the null hypothesis than under the alternative hypothesis.

False memory

An independent samples t-test was performed to compare participants in the false denial and honest control conditions on the proportion of misinformation details that they reported from the eyewitness account about the trauma analogue film. Participants in the false denial group did not report statistically significantly more misinformation related to the video ($M = 0.46$, $SD = 0.26$) than

participants in the honest control group ($M = 0.37$, $SD = 0.24$), $t(124) = -1.97$, $p = 0.051$, $d = 0.35$. We further estimated a Bayes factor ($BF_{01} = 0.92$) to examine how likely our data are under the null versus alternative hypothesis. This estimated Bayes factor showed that our data were around 0.92 times more likely under the null than the alternative hypothesis, showing no strong evidence.

Exploratory analyses

Correlational analyses

To explore whether true and false memory scores for the interview as well as for the video were correlated with each other – as false memory theories such as associative activation theory but also fuzzy trace theory would assume – we ran exploratory correlational analyses. These were not registered as exploratory analyses in the preregistration on the OSF but were added as exploratory analyses after data gathering. Neither in the honest control condition ($r = -0.12$, 95% CI $[-0.35; 0.14]$, $p = 0.37$), nor in the false denial condition ($r = 0.12$, 95% CI $[-0.13; 0.36]$, $p = 0.35$) were true and false memory scores from the interview statistically significantly correlated to each other. This trend was similar for memory scores for the video in both the false denial ($r = 0.24$, 95% CI $[-0.01; 0.46]$, $p = 0.06$) and honest control ($r = 0.15$, 95% CI $[-0.1; 0.38]$, $p = 0.24$) groups.

To further understand the effects of false denials on false memory reporting, we additionally ran correlational analyses between false memories reported for the video and false memories reported for the interview, split by honest control and false denial conditions. These were not part of the planned analyses in the OSF preregistration. In the honest control group, reports of false memories for the video and interview were statistically significantly positively correlated ($r = .29$, 95% CI $[0.048; 0.5]$, $p = 0.02$). Yet, in the false denial group, false memory for the interview and video were not statistically significantly correlated with each other ($r = -0.03$, 95% CI $[-0.27; 0.22]$, $p = 0.84$).

PANAS-T and false memory

As an exploratory aim, we wanted to assess whether participants' scores on the PANAS-T would be related to false memory formation. This is because previous research on the relationship between mood and false memory formation has been mixed (e.g., Bookbinder & Brainerd, 2016; Zhang et al., 2021). To this end, we performed a (preregistered) correlational analysis between both positive and negative PANAS-T subscales, and false memory reports for the video. Both correlations were statistically non-significant and rather small (with PANAS-T neg: $r = 0.02$, $p = 0.82$; with PANAS-T pos: $r = 0.06$, $p = 0.49$).

Revised IES and lying strategy (False denial vs honest control)

As a second (preregistered) exploratory aim, we investigated whether participants who falsely denied information

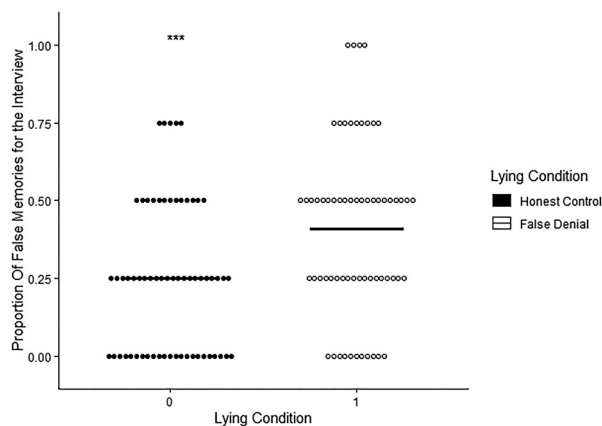


Figure 3. Proportion of false memory for the interview by lying condition. Note: Each dot represents one participant. Means are represented by bars. *** = $p < .001$.

versus who were honest in the interview differed in their IES scores one week after watching the trauma analogue video and after the lie occurred. We assessed this relationship because false denials are sometimes used as a coping strategy (Bain et al., 2015; Carver et al., 1989) to aid in dealing with negative experiences. If participants who used this strategy score different on the IES, this would have implications for whether or not false denials might successfully help coping. To this end, we performed independent samples Welch t-tests. Descriptive statistics for the IES scores split by experimental conditions are reported in supplementary materials (Table A4 in supplementary material). Participants who lied versus those who were honest did not differ statistically significantly in their self-reported level of intrusions, $t(122.76) = -0.04$, $p = 0.97$, $d = 0.01$. However, participants who falsely denied details from the trauma analogue film in session 1 had a statistically significantly lower avoidance score than participants who answered questions honestly, $t(118.87) = 2.37$, $p = 0.02$, $d = 0.42$ (see Figure 4). Because these data were not distributed normally, we additionally performed a non-parametric Mann–Whitney U test which supported the results of the t-test, $W = 2414.5$, $p = 0.035$, $r = 0.22$. On the revised IES total scores, participants in the false denial group did not differ statistically significantly from participants in the honest control group, $t(123.42) = 1.58$, $p = 0.12$, $d = 0.28$.

Discussion

The core aim of the current experiment was to investigate whether falsely denying having experienced certain traumatic events would affect the risk of reporting suggestion-based false memories for both the experienced event and previous conversations about it. Our most important findings are as follows. First, we replicated

denial-induced forgetting for conversations about a traumatic event. Second, false denials increased reporting of false memories for trauma-related discussions. We will now turn to the relevance of our findings.

First, in the present experiment, we replicated the denial-induced forgetting effect for a trauma-related discussion. Participants who falsely denied details recognised generally less information discussed in the interview as compared with participants in the honest control group. As in previous work showing denial-induced forgetting (e.g., Otgaar et al., 2014, 2016, 2020; Romeo et al., 2019) and especially using repeated denials (Battista et al., 2020), this effect was quite meaningful in that it constituted a 12% difference. This translates to around a one detail difference, which could be a relevant difference in a legal setting when testimony about conversations is involved. For example, this could make the difference between remembering or not whether they had previously talked about the perpetrator's clothing. This finding is not just in line with previous work, but also with our hypotheses. It further supports the notion that lying, and specifically false denials, leads to the forgetting of details about conversations. This was first applied to a trauma-analogue context by Romeo et al. (2019).

A new finding of this experiment is that false denials led to higher rates of reporting false memories for previous conversations, as compared with being consistently truthful. This effect had a size of Cohen's d of 0.61. In other words, 72.9% of data from participants in the false denial group (regarding misinformation endorsement) was above the mean rate of endorsement from the honest participants (Magnusson, 2021). Moreover, in absolute terms, the mean misinformation endorsement for the interview was 14% higher in the false denial than in the honest control group. This difference of 14 percentage points corresponds to around half a misinformation detail misremembered more in the false denial compared to the honest control condition.

At first glance, this finding *seems* to be in line with the tenets of fuzzy trace theory (i.e., FTT; Brainerd et al., 2008; Brainerd & Reyna, 2002). According to FTT (Brainerd et al., 2008; Brainerd & Reyna, 2002), because of denial-induced forgetting, participants in the false denial condition would rely more on the gist of the interview than control participants. This, in turn, would propel false memory rates, in line with the *true-false dissociation* principle of FTT (Brainerd et al., 2003, 2006). The latter is the principle of FTT which assumes a negative correlation between true and false memory rates in adult samples who store gist memory traces – thus, those with low true memory scores would have high false memory scores and vice versa. However, our exploratory analyses showed that no statistically significant correlations existed between true and false memory levels, and this is at odds with the principles of FTT.

The absence of such a correlation is not necessarily in line with the discrepancy detection principle either

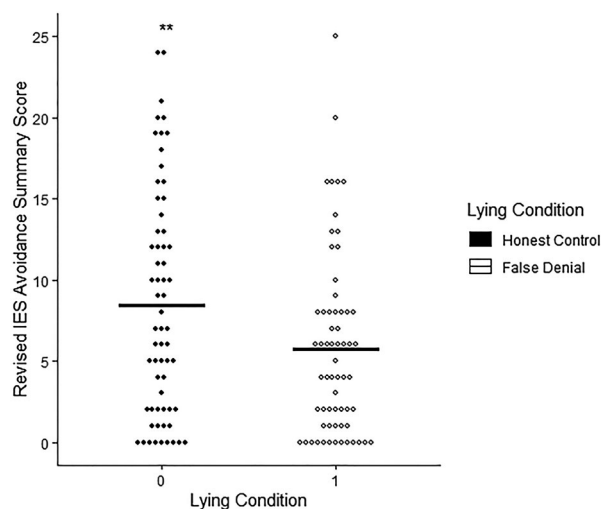


Figure 4. Summary IES avoidance scores by lying condition.

Note: Each dot represents one participant. Means are represented by bars. ** = $p < 0.05$.

(Tousignant et al., 1986). The reason for this is that similar to FTT, the discrepancy detection principle might assume that a negative correlation between true and false memory scores exists. Specifically, according to the discrepancy detection principle, if true memory is worse after false denial, participants would be less likely to detect that there is a discrepancy between the encoded information and misinformation. In turn, this would increase the risk to report misinformation in their own accounts. Thus, it is possible that there should be a negative correlation between true and false memory scores for the discussion. Yet, our correlational analyses show that this is not (statistically significantly) the case for our data.

Nevertheless, this does not necessarily mean that the discrepancy detection principle cannot be useful in explaining our data. This is because forgetting is not the only factor that might affect a participants' ability to detect discrepancy and thus false memory endorsement. Indeed, it is possible that a third variable could influence both forgetting and discrepancy detection independently of each other. The discrepancy detection principle might thus still be useful to interpret our results even though our data do not support a direct relation between forgetting and false memory endorsement. Indeed, Bain et al. (2015) who found that emotion-focused coping strategies are related to higher interview suggestibility, argued that the distribution of cognitive resources during an investigative or interrogative interview can also impact discrepancy detection. Specifically, these authors explained that those who employ an emotion-focused coping strategy such as false denial might divert cognitive resources away from efforts to encode and remember the event, and towards coping with the emotional nature of the information being discussed (Bain et al., 2015).

In line with this perspective, it is possible that our instruction to participants to deny several details from the traumatic events of the video shifted their cognitive resources *during the interview*. Specifically, the result would be that they employed more cognitive resources towards dealing with the highly emotional nature of the trauma-analogue video and fewer cognitive resources on encoding the conversation than participants who were not instructed to employ a coping strategy (i.e., honest control participants). As a consequence, the quality (or quantity) of the memory trace of the interview conversation might have been negatively impacted. A negative impact on the quality of the memory trace could explain both the denial-induced forgetting effect, but also the misinformation effect without presuming a direct correlation between the two effects. If falsely denying participants had a weaker memory trace for the interview, they would have been less likely to detect discrepancy between the stimulus and misinformation than consistently honest participants. Ultimately, this would explain the misinformation endorsement trend we found.

Of course, we did not manipulate or measure cognitive resources in the current experiment. Therefore, additional

research is necessary to investigate the role cognitive resources might have played here. Nevertheless, the idea that the mnemonic effects of false denial could be tied to the distribution of cognitive resources is somewhat in line with other work that ties cognitive resources to the mnemonic effects of false denials (Battista et al., 2021; Otgaar & Baker, 2018). For example, Battista et al. (2021) manipulated the amount of cognitive resources required during false denial and looked at memory for the conversation during which the denial occurred. They found that false denials which required more cognitive resources were related to increased commission errors as compared with denial strategies that required fewer cognitive resources in their execution. Of course, we did not directly manipulate cognitive resources in the current experiment, so at this point we can only hypothesise that indeed, false denials of highly emotional material shifted a person's cognitive focus towards coping and away from other tasks, such as remembering the conversation, and that this may be a reason that (interview) suggestibility was increased.

A second possible explanation for increased suggestibility to interview misinformation in participants in the false denial group is related to a shift in attention *during the misinformation phase*. Specifically, at the start of the second session participants in the false denial condition might have paid more attention to the summary of the previous session and interview (in which the misinformation was embedded). Increased attention to post-event information (including misinformation details) has previously been linked to increased misinformation endorsement in the retrieval enhanced suggestibility paradigm (Butler & Loftus, 2018; Gordon et al., 2015; Gordon & Thomas, 2017).

Both the quality of the original memory trace and the importance attached to details in the post-event information have been linked to such an attention shift (Butler & Loftus, 2018; Gordon et al., 2015). In line with this research, participants in the false denial group might have had a less detailed memory trace of the interview than participants in the honest control condition.² After all, participants in the false denial condition recognised fewer details from the interview than consistently honest participants who – as can be seen in their interview true memory scores – remembered the interview very well (on average, they correctly recognised 94% of discussed details). Moreover, participants who were asked to lie during the interview might have conveyed more importance to the memory interview than participants in the honest control group. Hence, for both of these reasons our argument is that participants in the false denial condition paid more attention to the interview misinformation. Ultimately, this could explain why this misinformation was more salient and endorsed more in the final memory test in the false denial group. After all, increased attention to post-event information has been directly linked to increased misinformation effects

(Gordon et al., 2015). Here also, it should be noted that we did not measure attention and that, therefore, our argument should be regarded as speculative in nature. In future research, measuring the reading time of the misinformation narrative (e.g., Gordon et al., 2015) could clarify a possible link between attention and misinformation endorsement after false denial.

Regarding memory for the traumatic event itself, we did not find that false denials impacted forgetting of the denied event or misinformation endorsement. This finding was contrary to our expectations. While we expected to replicate earlier forgetting effects (Battista et al., 2020; Romeo et al., 2019) due to using a trauma analogue stimulus and repeated denials, other studies have also failed to find an effect of false denials on event memory (e.g., Otgaar et al., 2014, 2016; Bücken et al., 2022). Our results are thus in line with most studies on false denials and memory. Generally, the mixed results regarding the mnemonic effects of false denials on event memory in the literature are also reflected by the Bayes Factor we calculated, which shows neither strong evidence for the null, nor alternative hypothesis.

How does our work fit with previous research on the intersection of lying and misinformation endorsement for memory of a witnessed event? There were only two previous studies that examined this link. Mangiulli et al. (2020) investigated whether a different deceptive strategy – feigning amnesia (i.e., claiming not to remember details related to an event) would affect reporting of misleading information about a mock-crime. In line with our own results, they were unable to find an effect of lying on reporting false memories of the witnessed event. In another experiment, Bücken et al. (2022), assessed whether denials of being a victim of abuse (in a memory roleplay) would impact misinformation reporting for abuse-related and – unrelated information from the abuse-scenario. Interestingly, false denials were related to increased reporting of false memories for abuse-unrelated information from the scenario which had not directly been denied. We did not replicate this effect, but this might be due to notable differences in the two experiments; While Bücken et al. (2022) employed a victim perspective and asked participants only to deny certain aspects, we employed a witness perspective and asked participants to deny all aspects of the witnessed event that they were asked about.

Limitations

There are several caveats worth mentioning. First, the data were collected during the COVID-19 pandemic so that data collection took place fully online via video calls. While this change in setting might have affected our results, we also suspect that the circumstances surrounding this pandemic (i.e., isolation, lockdowns) might have influenced participants' scores on the short form PCL-5 in the pre-screen, specifically reflected in responses to item 3 "Feeling

distant or cut off from other people." Indeed, a very high amount of participants were not eligible to take part in the sessions (i.e., over 25%) because they scored indicative of PTSD symptomatology on the short form PCL-5. Perhaps the sample of participants who were eligible was especially resilient, or otherwise different to participants in previous research.

Related to this latter limitation, participants in our sample were healthy university students who might differ from witnesses, victims and perpetrators who have experienced trauma and executed false denials. Yet the paradigm we used (i.e., the trauma film paradigm) in the current experiment is frequently used in trauma research, and participants' scores on the PANAS-S indicated that our stimulus successfully induced negative emotions, and reduced positive emotions. Moreover, participants reported a level of intrusions and avoidance on the IES that is indicative of medium clinical concern (Horowitz, 1982; Joseph, 2000), and in line with other research using trauma analogue stimuli. Therefore, our stimulus did induce appropriate emotional levels within ethical boundaries to study memory for traumatic events reliably.

Conclusions

To conclude, our results show that after falsely denying traumatic experiences, someone might (1) forget details that were discussed in conversations about the traumatic event during which denials occurred and may also (2) be more prone to misremembering what was discussed than someone who has not lied. This has important implications for testimony for conversations given by witnesses in court who are coming forward about traumatic experiences after previously denying that something happened. While the validity of memory for previous conversations – and thus testimony for conversations – might be negatively influenced by previous false denials, our data suggest that memory for the event itself is less influenced by previous denials.

Notes

1. A trauma analogue event is an event used in an experiment that evokes short-lived emotional states comparable to experiencing a traumatic event.
2. Or their access to the original memory trace might have been inhibited (see Otgaar et al., 2020).

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The data supporting the results and analyses of this paper can be accessed on the Open Science Framework where the data has been deposited (https://osf.io/hcunq/?view_only=08769a6c41794a419243f3edab5f3d01).

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