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What Can We Remember After Complex Denials?

The Impact of Different False Denials on Memory

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Abstract

False denial is a deceptive strategy that requires fewer cognitive resources than other strategies (e.g., simulating amnesia, fabrication). In the present experiment, we examined the effects of different types of false denials varying in cognitive load on memory. Participants (N = 159) watched a video (theft) and then answered some questions about it. Some participants had to tell the truth about the theft, while others were either asked to falsely deny all the event-related details (i.e., simple false denial) or to falsely deny just some details of the same event (i.e., complex false denial). After two days, all participants completed a memory task in which they truthfully recognized whether details were (i) discussed during the interview or (ii) seen in the video. Additionally, recall scores (i.e., correct details, omissions, commissions) of the memory for the event were assessed. Participants who falsely denied all details reported a higher memory impairment for the interview than the other groups. Interestingly, liars who were engaged in complex denying had the largest memory impairment for the event and reported more commissions than those in the simple false denial group. This experiment shows that under certain conditions, memory is increasingly impaired for high cognitive load lies.

Keywords: False Denials, Cognitive Load, Denial-Induced Forgetting, Memory Outcomes

Introduction

In legal cases, witnesses, victims, and suspects sometimes lie by *falsely* denying to have experienced an event or to have been involved in an experience (e.g., Block, Shestowsky, Segovia, Goodman, Schaaf, & Alexander, 2012; Goodman-Brown, Edelstein, Goodman, Jones, & Gordon, 2003; O'Donohue, Cummings, & Willis, 2018). Moreover, liars can decide to lie about certain aspects of the event and tell the truth about other aspects of the event. A recent survey showed that 13.1% (N = 194) of people who reported being a good liar declared to insert their lies into authentic information (Verigin, Meijer, Bogaard, & Vrij, 2019). Furthermore, good liars tend to include in false statements both truthful and verifiable information in order to gain credibility and plausibility of their statements (Leins, Fisher, & Ross, 2013; Nahari & Vrij, 2015; Verigin et al., 2019).

Moreover, it has been largely demonstrated that, in general, lying can affect memory and these effects are contingent on the performed deceptive strategy (e.g., Ackil & Zaragoza, 2011; Gombos, Pezdek, & Haymond, 2012; Mangiulli, van Oorsouw, Curci, Merckelbach, & Jelicic, 2018; Otgaar, Howe, Smeets, & Wang, 2016; Romeo, Otgaar, Smeets, Landström, & Boerboom, 2018; Romeo, Otgaar, Smeets, Landström, & Jelicic, 2019). Research has revealed that lying can lead to forgetting or false memory depending on which type of deceptive strategy was deployed (e.g., Otgaar & Baker, 2018). Indeed, liars can choose to deceive the listener using various paths, like simulating amnesia, fabricating a false version of the actual event, or falsely denying that an event happened (e.g., Block et al., 2012; Cima et al., 2002; Goodman-Brown et al., 2003; Gudjonsson et al., 2004; Rogers & Dickey, 1991). A recent line of research has suggested that implementing each of these three deceptive strategies requires different cognitive resources and this is what might cause different effects on memory (e.g., Otgaar & Baker, 2017). However, to date, it is unclear what the memory effects are when one specific deceptive strategy varies in the cognitive load required to apply it. To address this issue, in the present experiment, we focused on false denials strategy and we examined the effects of two types of false denials on memory: One

requiring a low cognitive load (i.e., everything was denied) and another one requiring a high cognitive load (i.e., certain items were denied and others had to be honestly answered).

False Denials and Memory

Several studies showed that false denials can lead to a detrimental mnemonic effect, also known as the *denial-induced forgetting* effect (i.e., DIF; Otgaar & Baker, 2018; Otgaar et al., 2016; Otgaar, Romeo, Howe, & Ramakers, 2018; Otgaar, Vieira & Lane, 2013). This specific effect refers to an impairment in recollecting which event-related details were lied (i.e., denied) upon during a first interview rather than to an impairment for the event. Typically, in these studies, the following procedure was used. Participants watched a mock crime video (or were presented with other stimuli, such as pictures) and were then instructed to falsely deny or tell the truth about what happened in the crime video. After a delay, all participants were instructed to genuinely answer to a source memory task, where they had to indicate their (i) memory for the actual event and (ii) memory for having discussed (i.e., denied or told the truth) about certain details during the first interview. The recurrent finding is that participants who had to deny during the first interview report a memory impairment for having discussed details during the interview as compared with participants who consistently told the truth. What makes this effect particularly intriguing is the fact that many studies have replicated this effect using different stimuli (e.g., pictures, virtual reality scenes), different tasks (e.g., recall memory task) and different populations (e.g., children and adults) (e.g., Otgaar et al., 2014; Otgaar et al., 2016; Otgaar et al., 2018; Romeo et al., 2018).

Interestingly, in a recent study, Romeo and colleagues (2018) found that denials might affect memory *also* for the experienced event and not only for what has been discussed during the interview. By following the typical procedure of false denial induction, the authors used a more ecological stimulus material (virtual reality (VR) scene, i.e., airplane crash), and justified their findings in relation to this kind of stimulus. That is, the VR scene permitted participants to be in a more realistic, but also emotionally negative situation. The authors stated that such manipulation

could have been the cause for deniers' forgetting the event, since participants could have intentionally attempted not to think of traumatic details seen, causing forgetting for the details of the experience. In another study, a memory forgetting for the event was also evinced (Romeo et al., 2019). In this study, participants were instructed to be involved in a mock crime (i.e., steal the answer of an exam from a professor's account) and then either asked to falsely deny details of the action, feign amnesia[1], or simply tell the truth. Romeo and colleagues found that being personally involved in the crime likely affected the impact of lying on memory. They did not show the typical mnemonic effect of false denials (i.e., DIF) on memory arguing that the failure of finding a DIF effect could be caused by the active involvement in committing the crime. However, the authors also found that when the deceptive strategy involved more cognitive resources an impairment for the memory for the interview occurred. Indeed, participants who feigned amnesia did show denial-induced forgetting. This latter finding supported the idea that a detrimental effect on memory could be due to the cognitive load required during the lying.

Based on this line of studies, it is reasonable to assume that different types of false denials can also impact memory in different ways depending on the cognitive load required to perform these false denials. To our knowledge, no studies have directly tested the idea that cognitive load can be a fundamental key to understand how each deceptive strategy affects memory. For this reason, we aimed to assess the memory effects when a simple deceptive strategy, such as false denials, becomes a more complex strategy due to a higher requirement of cognitive resources to perform the lie. To illustrate the rationale of our study, we will first elaborate on a recent framework that takes into account how false denials can affect memory as compared with other types of lying (e.g., fabrication and feigning amnesia). Subsequently, for the current experiment, we will specifically focus on assessing the effects of different types of false denials on memory for a crime.

[1] Feigning amnesia involves faking to not remember event-related details. That is, feigned amnesia refers to the deceptive strategy of pretending to suffer from memory loss for an experienced event (e.g., Christianson & Bylin, 1999; Van Oorsouw & Merckelbach, 2004).

The Memory and Deception Framework

Otgaar and Baker (2018) proposed the Memory and Deception framework (MAD) postulating that the act of lying might be conceptualized as developing along a continuum in terms of cognitive resources (e.g., Dianiska, Cash, Lane, & Meissner, 2019; Sporer, 2016, Vrij et al., 2006), according to the type of deceptive strategies adopted by individuals. More specifically, the authors argued that false denials require few cognitive resources because a deceiver who denies his/her involvement in a crime has to inhibit the truth by just negating that such event has actually happened (e.g., "*I did not abuse the girl"*). Feigning amnesia can be seen as a strategy requiring an intermediate amount of cognitive resources as in this case of someone who simulates memory loss who can declare to suffer from a memory loss. By contrast, fabrication implies a high amount of cognitive resources. Indeed, a liar who fabricates an entire new version of an event has to inhibit past information and remember the truth while coming up with a false account of the event. Undoubtfully, such effort requires more cognitive resources than simply falsely denying an experience (Ackil & Zaragoza, 2011; Chrobak & Zaragoza, 2008, 2012; Vrij et al., 2006). Thus, according to the MAD framework, when deception involves few cognitive resources, like in the case of false denial, omission errors (e.g., forgetting) are more likely to occur than when many cognitive resources are required, like in the case of fabrication. For the latter, it might be the case that commission errors (e.g., false memories) are more likely to occur.

-----insert Figure 1 about here------

Although no direct evidence is available, several prior studies hint to the possibility that different mechanisms might play a role in these divergent effects (i.e., DIF, forgetting, memory errors), such as lack of rehearsal (Bylin & Christianson, 2002; Van Oorsouw & Merckelbach, 2004), or source monitoring errors (Johnson, Hashtroudi, & Lindsay, 1993). For example, in the studies showing that false denials lead to omissions errors (e.g., Otgaar et al., 2016; Viera & Lane, 2013), the authors explained such memory outcomes in terms of inhibitory effects caused by having

denied details of the event. Specifically, scholars have argued that -- by denying the event-related information -- deniers inhibit the memory traces referring to the original event. This leads to difficulty retrieving the same details (i.e. omissions) in a subsequent moment. Research on the effects of feigned amnesia on memory supports the idea that cognitive resources play an important role in understanding the relationship between lying and memory. Indeed, research on feigned amnesia has shown that such a strategy can lead to omissions due to a lack of rehearsal of event-related details when a simple variant is employed (i.e., few cognitive resources: "I do not remember") (e.g., Bylin and Christianson, 2002; Christianson and Bylin, 1999; Mangiulli et al., 2018; Mangiulli, Lanciano, van Oorsouw, Jelicic, & Curci, 2019; Romeo et al., 2019; Van Oorsouw and Merckelbach, 2004, 2006) or to commissions errors. In the latter case, errors are due to source monitoring errors when feigners introduce new and fabricated details in their account for the original event (i.e., many cognitive resources: "I do not remember" plus adding a fabricated story) (Mangiulli et al., 2018; Mangiulli et al., 2019; Otgaar & Baker, 2018; Van Oorsouw and Giesbrecht, 2008;). Finally, research on fabrication has demonstrated that such a lying strategy leads individuals to consider their own fabrications as true details of the event, i.e. commission errors (e.g., Ackil & Zaragoza, 2011; Chrobak & Zaragoza, 2008, 2012; Gombos et al., 2012; Pickel, 2004; Polage, 2004; Polage, 2012; Van Oorsouw & Giesbrecht, 2008; Zaragoza, Payment, Ackil, Drivdahl, & Beck, 2001) and these memory errors takes place as a result of source monitoring errors (e.g., Chrobak & Zaragoza, 2008, 2012). In other words, during the retrieval of the actual event, fabricators have problems to distinguish false and self-generated details from actual details of the event. Thus, individuals unintentionally include in their genuine recall of the event self-generated false details (i.e., commissions) due to a confusion between what was originally experienced and what was subsequently fabricated.

Overall, previous studies suggest that deceptive strategies requiring few cognitive resources lead to forgetting while deceptive strategies requiring high cognitive resources lead to commission

errors. A critical test to verify whether cognitive resources are important in the effects of lying on memory is, for example, to examine the effects of one particular deceptive strategy on memory, thereby varying the level of cognitive resources required to use such a strategy. One possible way to manipulate the amount of cognitive resources during lying is adopting a manipulation based on the *dual-task paradigm* (Baddeley & Hitch, 1977). A dual task procedure requires a person to execute two tasks concurrently and the idea behind this is that cognitive resources are limited, shareable and can be divided into various tasks (e.g., Kahneman, 1973; Navon & Gopher, 1979; Wickens, 1991). This means that the two tasks interfere with each other and the cognitive resources, normally used for one task, are split into the execution of both tasks. Thus, in our experiment, we adopted this procedure to test the effects of different types of false denials on memory. Hence, our manipulation was executed on false denials and consisted of the simultaneous execution of two tasks. In particular, in one of the three experimental conditions (i.e., complex false denial group), the experimenter asked participants to keep in mind some items that they could not lie about (first task) and to deny on the other items of the event (second task). Findings from the above-reviewed studies suggest that the effects of lying on the original memory might perhaps largely depend on the cognitive load required by lying. This might mean that when false denials become more cognitively taxing, their mnemonic consequences might resemble mnemonic effects of other high cognitively taxing lies, such as fabrication.

The Present Experiment

In the present experiment, we focused on different types of false denials. Participants were presented with a video of a theft and then answered questions about it. Subsequently, they either denied all details (i.e., low cognitive load condition; simple false denials) or denied certain details (i.e., high cognitive load condition; complex false denials) or genuinely talked about details of the event (i.e., truth telling condition). Specifically, participants in the complex denial condition had to simultaneously perform two tasks: (1) remembering details that they could not deny and (2) denying

the rest of the details. Such a dual task has been shown to be cognitively demanding (e.g., Bourke, Duncan, & Nimmo-Smith, 1996; Darling & Helton, 2014; Green, Draper, & Helton, 2013; Wickens, 2002, 2008). Finally, after two days, all participants received a source memory task which had to be completed truthfully. They were requested to indicate their memory (i) for the interview and (ii) for the video.

Our hypotheses were that complex denials would differentially impact the individuals' memory than the standard denial as more cognitive resources would be required to execute a complex denial strategy. In particular, we expected that when participants would recall the details seen in the video, participants in the low cognitive load condition (i.e., simple false denials group) would have more omission errors than the truth-telling and complex false denials groups (Hypothesis1); while participants in the high cognitive load condition (i.e., complex false denials group) would have more commission errors than the truth-telling and simple false denial groups (Hypothesis 2). In addition, we expected to replicate the denial-induced forgetting effect in both the liars (i.e., simple and complex false denials) groups and to find a larger effect in the complex false denial group (Hypothesis 3).

Method

Participants

Using G*Power (Faul, Erdfelder, Lan, & Buchner, 2007), an a priori power analysis for a one-way ANOVA between three groups with a power of 0.80 and medium effect size ($f = 0.25$) indicated that a sample of 159 participants was required. A group of 168 students from the University of Bari "Aldo Moro" participated in the present study. Nine participants were excluded because they did not comply with the instructions during the first session leaving 159 participants ($M_{age} = 22.52$, $SD = 4.35$, range 18-59, 132 women). The study was conducted in a psychological laboratory, where participants were tested individually. Participants did not receive any

compensations (e.g., course credit, reward), but took part in the experiment voluntarily. The ethical committees of the Department of Education, Psychology, Communication of the University of Bari "Aldo Moro" and of the Faculty of Law of the Catholic University of Leuven approved the study (protocol number G- 2019 05 1655). The study was preregistered (https://osf.io/symx8) and all the data and materials can be accessed on the Open Science Framework: https://osf.io/zhjt3/.

Materials

Video. We used a video that has been previously used in other memory studies (e.g., Otgaar et al., 2014, 2016; Takarangi, Parker, & Garry, 2006). The video, of the duration of 6.5 minutes, is called "Eric the electrician". In this video, an electrician (i.e., Eric) is fixing some objects in a house and stealing various objects, such as jewellery and CD.

Design and Procedure

The experiment used a between-subjects design (Condition: Simple False Denial, Complex False Denial, Truth-Telling). The dependent variables were the source monitoring scores (i.e., having discussed items vs. having seen items) and the recall scores for the crime-related event (i.e., correct details, omissions, and commissions). Participants were randomly assigned to one of the three different conditions (Simple False Denial: n = 53, Complex False Denial: n = 53, Truth Telling: n = 53). The study was carried out in two sessions with 48 hours between each session. Each participant was tested in both sessions by one of three experimenters (i.e., first author and two research assistants).

Session 1

Video Presentation. After signing the informed consent, participants watched the video "Eric the electrician". Then, they were involved in a 5-min filler task (i.e., playing the videogame Candy Crush).

Baseline Memory Test. Immediately after the filler task, to be certain that participants properly encoded the video, a baseline memory test was performed. All participants answered 10

questions regarding details that were present in the video (e.g., "*What vehicle did Eric arrive with?"*) and provided a memory and belief rating for each question (e.g., "*Do you actually remember seeing what vehicle Eric arrived with?":* 1 = no memory at all, 8 = clear and complete memory; "*How likely is that you saw what vehicle Eric arrived with?":* 1 = definitely not likely, 8 = definitely likely; Scoboria, Mazzoni, Kirsch, & Relyea, 2004). Then, they engaged in a second filler task for 5 minutes (i.e., Candy Crush).

False Denial Phase. In this phase, participants answered 12 questions about the crime watched in the video, according to their experimental condition. These 12 questions were composed of 9 of the previous 10 questions of the baseline memory test and 3 different questions. Moreover, for all three groups, the interview consisted of 8 questions containing items seen in the video (i.e., true items e.g., "*In which room did Eric open a window?"*) and 4 questions pertaining to details not shown in the video (i.e., false items e.g., "*Which body part did Eric injure while he was in the house?")* (see Appendix A).[2] All participants were asked to imagine being at a police station and to be interviewed by a policeman (i.e., experimenter) as an eyewitness of the crime. Participants in the truth-telling condition were asked to truthfully answer to each question (e.g., *"What vehicle did Eric arrive with?"*, correct answer: *blue van*), while participants in the simple false denial condition were instructed to deny in response to each question (e.g., *"What vehicle did Eric arrive with?"*, answer instructed: *"Eric did not arrive with a vehicle"*). For participants in the complex false denial condition, additional instructions were provided: they were told that the policeman knew some aspects of the event because of a hidden camera in the house (6 items in total: 4 true and 2 false; e.g., true item seen in the video: the drink that Eric took from the fridge and false item not seen in the video: the pet in the living room). The other six items were not known by the policeman. Thus, the experimenter read the six (of twelve) known details to participants and, immediately after, asked them to repeat these six details in order to assure that they were correctly encoded. Then, by

[2] Note that, because the false items concerned information that never occurred in the video, when participants denied on such items they were telling the truth.

keeping in mind those six items, complex false denial participants underwent the interview (twelve questions: 6 questions on items known by the policeman and 6 on items not known). That is, those participants told the truth for the questions related to the aspects known (both the 4 true and the 2 false details) by the policeman (e.g., *question on true detail: "What drink did Eric take from the fridge?"*, correct answer: *"Coca-cola" and question on false detail: "What kind of pet was in the living room?",* correct answer: *"There was no pet in the living room"*) and lied (i.e., denied) at the questions of the details that were unknown to the police officer (e.g., *"What did Eric steal?"*, answer instructed: *"Eric did not steal anything"*).

Session 2

Final Memory Test. After a delay of 48 hours, participants completed a source memory task of 16 questions. The questions were composed of 8 questions on details discussed (i.e., denied or told the truth) during the interview and the rest were 8 questions not discussed. For the complex denial group, 5 of the 8 items were denied and the rest (3) were honestly answered (e.g. details that the interviewer was supposed to know). Moreover, 10 questions were on true details and 6 questions referred to false details (see Appendix B). To make sure that all participants complied with the instructions, the experimenter provided participants with an example of the five questions that they had to answer for each detail. In addition, the experimenter gave also an example of the type of answer required (i.e., YES/NO or recall of the detail). All participants (i.e., simple false denial, complex false denials, and truth-telling) had to respond truthfully. For each question, participants had to indicate their (i) memory for the interview (e.g., "*When we spoke during the first session, did we discuss what vehicle Eric arrived with?",* answer: *Yes/No*), and (ii) the memory for what was seen in the video (e.g., "*When watching the video, did you see what vehicle Eric arrived with?",* answer: *Yes/No*). The memory for the event was also measured with an open question where participants had to indicate what detail they remember having seen in the video (e.g., "*When watching the video, did you see what vehicle Eric arrived with?",* answer: detail remembered).

Moreover, a memory rating (e.g., "*Do you actually remember seeing what vehicle Eric arrived with?":* 1 = *no memory of the event at all*; 8 = *clear memory of the event*) and a belief rating (e.g., "*How likely is it that you saw what vehicle Eric arrived with?":* 1 = *definitely not likely*, 8 = *definitely likely*) had to be completed for each item. At the end of the memory task, participants were thanked and debriefed.

Scoring

The final memory task was scored considering the source monitoring [i.e., a) items seen in the video; b) items discussed during the interview] and the recall scores [i.e., c) correct details, d) omissions, e) commissions].

The scores of source memory task were calculated attributing one point for each correct answer to the questions: (a)*"When watching the video, did you see what vehicle Eric arrived with?"* (correct answer*: yes;* score assigned: 1); (b) *"When we spoke during the first session, did we discuss what vehicle Eric arrived with?"* (correct answer*: yes;* score assigned: 1).

Recall scores were calculated following a scoring system adopted in a previous study (Battista, Mangiulli, Curci, Herter, & Otgaar, 2020). Specifically: (c) For the correct details score, one point was assigned for each correct answer (e.g., *"When watching the video, did you see what vehicle Eric arrived with?";* correct answer: *blue van*), a half-point was given to a partially correct answer (e.g., *van*), while a score of zero was given to the incorrect answer (e.g., *green bus*) and when no answer was provided (e.g., "*I do not remember"*); (d) for omissions score, one point was given when participants provided no answer (e.g., *I do not remember*); (e) for commissions score, one point was attributed when participants provided a completely wrong answer (e.g., *green bus*) or a half-point was assigned when the provided answer was partially distorted (e.g., *white van*).

The source monitoring and recall scores for all the items of the final memory task and just for the items discussed during the interview were calculated. All the scores were summed considering all the items (maximum score: 16) and the items discussed during the interview

(maximum score: 8; maximum score for complex denial group: 5). Due to our manipulation in the complex false denial group, the source monitoring score of memory for the interview considering only the items discussed was calculated taking into account only the 5 items denied and not the 3 items honestly answered. We decided to consider only the 5 items denied in order to isolate the memory effect on memory due to having denied items under a more demanding circumstances, rather than an overall effect of the cognitive load imposed. For all scores, proportions were computed dividing the score obtained by each participant by the maximum score of the memory score (i.e., 16, 8, or 5). Moreover, the memory rating and the belief rating scores were calculated summing the score reported at each question.

The final memory test was scored by the first author and a researcher assistant. The Interclass Correlation Coefficient (ICC; i.e., Pearson's r) average measure for the number of correct details was 0.82, $p < .001$, while the ICC average measure of omission and commission errors was 0.89 and 0.75, $p_s < .05$, respectively.

Results

Baseline Memory performance

A one-way ANOVA on the baseline memory score of the three groups (i.e., simple false denials, complex false denials, truth-telling) was conducted in order to understand whether the video was correctly encoded by all participants. The overall mean proportion for the first memory test ($M = .75$; $SD = .17$) suggests that the crime video was not too difficult for the participants. Moreover, the analysis did not demonstrate a statistically significant difference between groups (simple false denial: $M = .77$, $SD = .17$, complex false denial: $M = .73$, $SD = .18$, truth telling: $M = .75$, $SD = .17$), $F(2, 156) = .76$, $p = .47$, $\omega^2 = .000$.

Final Memory performance[3]

[3] We also conducted additional analyses on the memory and belief ratings and on the scores of true and false details. We reported these analyses in the supplementary materials on the OSF: https://osf.io/zhjt3/

Memory for the Video

One-way ANOVAs were run on the memory for the video scores with the interview condition as a between groups factor (Condition: simple false denials, complex false denials, truth-telling). More specifically, the statistical analyses were conducted on the overall score for the final memory test and on the score for items discussed during the interview in terms of a) memory performance for items seen in the video (source monitoring score) and c) correct details, d) omission errors and e) commission errors (recall scores) (see scoring section).

Source Monitoring Score. Regarding the overall participants' memory performance for what was seen in the video (16 questions, e.g., "*When watching the video, did you see what vehicle Eric arrived with?"*), analysis showed a statistically significant difference between conditions, $F(2, 156) = 3.91$, $p = .022$, $\omega^2 = .04$. Specifically, post hoc Bonferroni comparisons demonstrated that participants' memory performance for having seen details in the video was lower for the complex false denial group ($M = .74$, 95% CI [.71, .76]) than for the simple false denial group ($M = .79$, 95% CI [.76, .82]), $p = .02$, 95% CI [.007, .10], $d = .50$). Other differences were not statistically significant (all $p_s > .05$).

Regarding participants' memory for what was seen in the video of details that were only discussed during the interview (8 questions), differences did not reach statistical significance, $F(2, 156) = 2.32$, $p = .10$, $\omega^2 = .02$.

Recall scores

Correct details. With respect to the overall score of correct details (e.g., *"When watching the video, did you see what vehicle Eric arrived with?;* correct answer: "Blue van"; participants' answer: *"Blue van",* score assigned: 1 or *"Green van"*, score assigned: 0.5), the three groups did not statistically differ from each other, $F(2, 156) = 2.36$, $p = .10$, $\omega^2 = .02$. However, the groups differed from each other in terms of correct details recalled for the items discussed during the

interview, $F(2, 156) = 3.07$, $p = .049$, $\omega^2 = .03$. However, post hoc analyses did not reveal any statistically significant differences between conditions (all $p_s > .05$).

Omission Errors. Concerning the omission errors score (*"When watching the video, did you see what vehicle Eric arrived with?";* participants' answer: *"I do not remember"* or *no answer,* score assigned: 1), the analyses on both the overall score and on the score for the items discussed during the interview did not show statistically significant differences, $F(2, 156) = .35$, $p = .71$, $\omega^2 = .000$, and $F(2, 156) = .24$, $p = .78$, $\omega^2 = .000$, respectively.

Commission Errors. Regarding the overall score for the commission errors (*"When watching the video, did you see what vehicle Eric arrived with?"*; correct answer: "Blue van"; participants' answer: *"Green car",* score assigned: 1 or *"Green van"*, score assigned: 0.5), no statistically significant difference between groups was found, $F(2, 156) = .71$, $p = .50$, $\omega^2 = -.004$. Interestingly, analysis conducted on the commissions scores of items discussed during the interview demonstrated a statistically significant difference between groups, $F(2, 156) = 3.36$, $p = .04$, $\omega^2 = .03$. Post hoc Bonferroni comparisons showed that commission scores for items discussed during the interview was statistically higher for the complex false denial group ($M = .18$, 95% CI [.14, .22]) than for the simple false denial group ($M = .12$, 95% CI [.08, .15], $p = .04$, 95% CI [-.13, -.002], $d = .44$). Other differences were not statistically significant (all $p_s > .05$).

Memory for the Interview

A one-way ANOVA was conducted on the overall score for the final memory test and on the score for items discussed during the interview in terms b) memory performance for items discussed during the interview (source monitoring score) (see scoring section).

Source Monitoring Score. Regarding the overall memory performance for what was discussed during the interview (16 questions, e.g., "*When we spoke during the first session, did we discuss what vehicle Eric arrived with?"*), analysis showed that the groups statistically differed from each other, $F(2, 156) = 16.66$, $p < .001$, $\omega^2 = .17$. Post hoc Bonferroni comparisons showed

that memory for the interview was statistically lower for participants in the simple false denial group (M = .71, 95% CI [.69, .73]) than for both participants in the truth-telling group (M = .79, 95% CI [.77, .82], p < .001, 95% CI [.05, .12], d = 1.01) and for participants in the complex false denial group (M = .78, 95% CI [.76, .80], p < .001, 95% CI [-.11, -.03], d = .92). Other differences were not statistically significant (all p_s > .05).

Regarding the memory for the interview of only items discussed (8 questions for simple false denials and control groups, 5 questions for complex false denials group), the three groups statistically differed from each other, $F(2, 156) = 8.86$, $p < .001$, $\omega^2 = .09$. Post hoc Bonferroni comparisons showed that memory for the interview considering only items discussed was lower for participants in the simple false denial group (M = .73, 95% CI [.69, .76]) than for participants in the truth-telling group (M = .86, 95% CI [.81, .90], p < .001, 95% CI [.05, .21], d = .89). Furthermore, memory for the interview was statistically lower for participants in the complex false denial group (M = .76, 95% CI [.70, .81]) than for participants in the truth-telling group (p = .008, 95% CI [.02, .17], d = .53). No other differences were statistically significant (all p_s > .05).

-----insert Table 1 about here-----

Discussion

Previous research has demonstrated that false denials have memory undermining effects (e.g., Otgaar et al., 2016; Otgaar et al., 2018). It has been argued that this effect might depend on the cognitive resources implicated during the execution of false denials (Otgaar & Baker, 2018). The present experiment examined whether different memory outcomes would be observed when false denials would differ in terms of cognitive resources. In line with the MAD framework (Otgaar & Baker, 2018), we indeed found that when cognitive resources are varied within one particular deceptive strategy (i.e., false denial), memory is differentially affected. Specifically, we observed the following results. First, our findings demonstrated that when false denials were exerted by using high cognitive load, participants showed a stronger memory impairment for the event as compared

with that exhibited by simple denial participants. Moreover, in line with our prediction (Hypothesis 2), we found that false deniers in the high cognitive load condition reported more commissions than deniers in the low cognitive load condition. Second, we replicated the standard *denial-induced forgetting* effect (DIF; Otgaar et al., 2016) (Hypothesis 3). That is, the simple false denials group showed the lowest memory performance for the interview than the other groups.

To begin with, in accordance with our general expectation, we found that the high cognitive load condition (i.e., complex false denials) impaired memory for the event more than the low cognitive load condition (i.e., simple false denials). Indeed, false deniers in the high cognitive load condition were less able than those in the simple cognitive load to recognize the details seen in the video. This effect was also detected in the analyses on the recall scores (i.e., the correct details reported during the recall). Furthermore, and as expected (Hypothesis 2), this lower memory recall for the event of false deniers in the high cognitive load went hand in hand with more commission errors in this group. Hence, it seems to be the case that engaging in more effortful denying did not only result in more commission errors, but it also increased the forgetting of the event. Irrespective of the current state of the MAD framework (Otgaar & Baker, 2018), wherein the act of each deceptive strategy is associated with a specific degree of cognitive resources and, in turn, with a unique memory outcome (i.e. omissions or commissions), we suggest that the link between every strategy and the cognitive load required to engage in each of them is more complex than it was initially thought. For example, in our study when more cognitive effort is exerted in false denials, two types of memory errors might ensue: Increased forgetting and increased levels of commission errors. Our findings appear to converge towards the idea that there would not be *one* continuum in terms of cognitive resources from false denials (low levels cognitive resources) to fabrication (high levels of cognitive resources). What seems to be the case is that each deceptive strategy might have its own continuum in terms of cognitive resources. Consequently, each strategy can simultaneously lead to different memory outcomes according to the amount of cognitive resource invested while

lying (i.e., omissions and commissions). Of course, additional research is needed to differentiate the amount of cognitive resources involved in each deceptive strategy.

Our findings that especially memory for the event was undermined when executing a complex false denial parallels previous work in which false denials were also shown to impact memory for the event (e.g., Romeo et al., 2018). Perhaps denying having experienced highly vivid stimuli is sufficiently cognitively taxing to impair memory performance. Another reason for increased forgetting as a result of more cognitive resources involved is that it is related to inhibition processes undermining memory performance. That is, when individuals deny details of an event, they are forced to suppress memory of such details making their recall harder over time (e.g., Otgaar et al., 2016). That is particularly strong when cognitive resources are impaired by a high cognitive load manipulation. Indeed, in the high cognitive load condition, participants needed to split their cognitive resources into a simultaneous implementation of two tasks. Participants in the high cognitive load condition used a part of their resources to suppress the truth while lying and the rest to remember the actual details of the event. Hence - although one might argue that in this condition participants could have lower inhibition effect due to the fact they had to suppress half of the details - the suppression (e.g., Anderson & Green, 2001; Anderson & Nelly, 1996; Basden, Basden, & Gargano, 1993) effects of denying were further amplified by the fact that those participants split the resources normally implicated in one task in the execution of two tasks. Moreover, if on the one hand our manipulation resulted in an increase of the suppression processes, on the other hand such a situation of the high cognitive load has made deniers more prone to source monitoring errors (e.g., Johnson, Hashtroudi, & Lindsay, 1993) – like, for instance, when people lie by fabricating - resulting in a higher amount of commissions.

Results for the low cognitive load condition replicated the standard *denial-induced forgetting* effect (Otgaar et al., 2016) and we found partial support for (Hypothesis 3). Indeed, we found that deniers in the simple cognitive load condition reported the lowest memory performance with respect

to details discussed during the interview. This finding is in line with previous experiments (e.g., Otgaar et al., 2014; Otgaar et al., 2016; Otgaar et al., 2017; Otgaar et al., 2018) that have adopted the classic procedure requiring participants denying all the aspects of the event. The effect has been typically explained considering a lack of rehearsal for the interview. That is, the instruction to deny all the answers can result in a poor rehearsal of the interview resulting in weaker memory performance for the interview (e.g., Otgaar et al., 2014; Vieira & Lane, 2013). However, in contrast to the MAD framework, and to our expectation, we did not find a larger *denial-induced forgetting* effect in the complex false denial group. Moreover, this result is in contrast with a study by Romeo and colleagues (2019) showing that also liars using a more demanding deceptive strategy (i.e., feigned amnesia) can have an impairment of the memory for the interview (i.e., DIF effect). This counterintuitive result could be caused by the fact that having to perform a more complex task makes people more attentive to what they were discussing rather than to the event. That is, being more focused on the discussion allows participants to have a better consolidation of memory for the interview.

A second explanation could be related to the rehearsal of information. That is, participants in the complex false denial group -- due to the cognitive load manipulation – might have rehearsed the details of the interview with the experimenter. Thus, it could be that rehearsal might have led participants in the complex false denial to consolidate the discussed details during the interview, resulting in better memory for the interview as compared with the simple false denial group. However, this explanation can only account for the differences between deniers (i.e., simple and complex). Indeed, if the rehearsal had permitted to better consolidate the details to be discussed we should have found an overall better memory performance for the interview for the complex false denial group than for the truth-telling group. However, we found the opposite result. Undoubtedly, future studies are needed to examine whether denial-induced forgetting is really affected by the amount of involved cognitive resources.

Some limitations are important to mention. One critical point of our study is that participants were eyewitnesses of a simple video which is certainly different from more ecologically valid experiences that participants underwent in previous research (e.g., virtual reality; Romeo et al., 2018). This implies that we cannot fully generalize our findings to real-life contexts, wherein people lie about something that has a stronger impact on one's emotional state. Second, dual tasks as the one we used in the present experiment were shown to be cognitively taxing (e.g., Bourke, Duncan, & Nimmo-Smith, 1996; Darling & Helton, 2014; Green, Draper, & Helton, 2013; Wickens, 2002, 2008). Of course, it is unclear to what extent they are taxing in our specific design and this needs to be examined in future work. Moreover, future studies on this topic could include in their design a further experimental condition to compare our denial strategies with the strategy of fabrication. In line with the idea that fabrication is the most demanding strategy, adding this condition could help to better elucidate whether a complex denials strategy may have similar effects to the ones occurring following fabrication. Finally, the current experiment adopted an eyewitness perspective. However, false denials are often used also by offenders or victims during legal trials. Hence, a critical issue for future studies could be to verify what kind of memory effects occur when participants assume a first-person perspective.

In sum, our study suggests that cognitive resources are involved in the link between lying and memory. On the one hand, in the low cognitive load condition, participants seem to adopt all their cognitive resources in the inhibition of the actual details resulting in the typical *denial-induced forgetting* effect. On the other hand, in the high cognitive load condition participants seem to employ a part of their resources in the suppression of the actual details and another part in honestly remembering the actual details, undermining memory for the event by increasing forgetting and commission errors. However, such pattern was not observed when focusing on memory for the interview. Examining which factors such as cognitive resources underpin the effects of lying on memory might provide us with a more complete picture on which internal mechanisms might

contaminate memory. Moreover, having such a more complete picture might potentially have relevance for cases in which eyewitness, victims, or suspects lied about their experiences.

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No potential conflict of interest was reported by the authors.

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Figure 1. The association between the deceptive strategies, cognitive resources and memory outcomes.

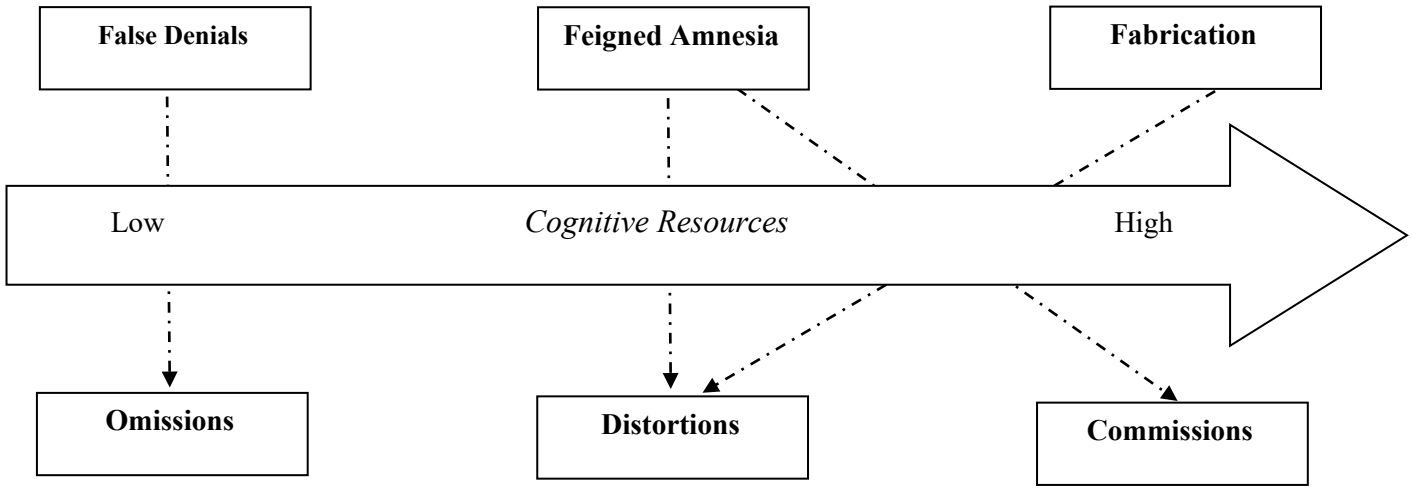

Table 1. Descriptive statistics of the memory (i) for the video and memory (ii) for the interview considering the three groups (i.e., truth-telling, simple false denials, complex false denials).

Measures	Truth-telling		Simple False Denials		Complex False Denials	
	Overall Score	**Discussed Items Score**	**Overall Score**	**Discussed Items Score**	**Overall Score**	**Discussed Items Score**
Recognition						
Memory for the video	.75 (.09) 95% CI[.73, .78]	.77 (.14) 95% CI[.73, .81]	.79[a] (.09) 95% CI[.76, .82]	.81 (.12) 95% CI[.77, .84]	.74[a] (.12) 95% CI[.70, .77]	.74 (.15) 95% CI[.70, .79]
Memory for the interview	.79[b] (.09) 95%CI [.77, .82]	.86 (.17) 95% CI[.81, .90]	.71[b,c] (.08) 95% CI[.69, .73]	.73 (.12) 95% CI[.69, .76]	.78[c] (.07) 95% CI[.76, .80]	.76 (.20) 95% CI[.70, .81]
Recall						
Memory for the video	.29 (.14)	.35 (.19)	.31 (.13)	.37 (.17)	.26 (.12)	.29 (.15)
Correct details	95% CI[.25, .33]	95% CI[.29, .40]	95% CI[.28, .35]	95% CI[.32, .42]	95% CI[.23, .29]	95% CI[.25, .33]
Omission errors	.58 (.16) 95% CI[.54, .63]	.52 (.20) 95% CI[.47, .58]	.58 (.16) 95% CI[.54, .63]	.52 (.19) 95% CI[.47, .58]	.60 (.13) 95% CI[.57, .64]	.55 (.18) 95% CI[.50, .59]
Commission errors	.14 (.10) 95% CI[.11, .17]	.13 (.12) 95% CI[.10, .16]	.14 (.12) 95% CI[.10, .17]	.11[d] (.10) 95% CI[.09, .14]	.16 (.11) 95% CI[.13, .19]	.18[d] (.18) 95% CI[.13, .23]

The first column of each group refers to the overall scores, the second one refers to the score of items discussed during the interview. The results show the mean proportions and 95% CI reported by participants and between parentheses the standard deviations. Same letters display significant differences between groups at least at $p < .05$.

Appendix A

	Truth-Telling	*Simple False Denials*	*Complex False Denials*
True Details			
Question 1	Honestly Answered	Denied	Honestly Answered
Question 2	Honestly Answered	Denied	Honestly Answered
Question 4	Honestly Answered	Denied	Denied
Question 6	Honestly Answered	Denied	Denied
Question 8	Honestly Answered	Denied	Honestly Answered
Question 9	Honestly Answered	Denied	Honestly Answered
Question 10	Honestly Answered	Denied	Denied
Question 12	Honestly Answered	Denied	Denied
False Details			
Question 3	Honestly Answered	Denied	Honestly Answered
Question 5	Honestly Answered	Denied	Honestly Answered
Question 7	Honestly Answered	Denied	Denied
Question 11	Honestly Answered	Denied	Denied

Table shows the 12 questions discussed during the lying phase according to the experimental instructions (i.e., honestly answered or denied). Moreover, the table shows the 8 questions on items seen in the video and the 4 questions on items not seen in the video.