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Maltreatment increases spontaneous false memories but decreases suggestion-induced false memories in children

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We examined the creation of spontaneous *and* suggestion-induced false memories in maltreated and non-maltreated children. Maltreated and non-maltreated children were involved in a Deese–Roediger–McDermott false memory paradigm where they studied and remembered negative and neutral word lists. Suggestion-induced false memories were created using a misinformation procedure during which both maltreated and non-maltreated children viewed a negative video (i.e., bank robbery) and later received suggestive misinformation concerning the event. Our results showed that maltreated children had higher levels of spontaneous negative false memories but lower levels of suggestion-induced false memories as compared to non-maltreated children. Collectively, our study demonstrates that maltreatment both increases and decreases susceptibility to memory illusions depending on the type of false memory being induced.

Statement of contribution

What is already known on this subject?

- Trauma affects memory.
- It is unclear how trauma affects false memory.

What does this study add?

- This study focuses on two types of false memories.

A key issue in legal cases concerns the reliability of testimonies. This is especially relevant in cases in which forensic technical evidence is lacking and legal decisions are based solely on testimonies from child witnesses or victims. For example, child abuse cases are commonly characterized by the presence of children's statements and the absence of any other evidence (Brackmann, Otgaar, Sauerland, & Jelicic, 2016; Howe & Knott, 2015). In such cases, it is of considerable importance to determine the reliability of children's eyewitness accounts and decide whether statements about these events have been contaminated with errors of omission or commission (i.e., false memories).

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Many children involved in legal cases have a history of maltreatment. A heated debate in the memory literature is whether a history of trauma might affect children's memory, rendering them more susceptible to the formation of false memories. What is important to consider here is the distinction between false memories that arise spontaneously (Howe & Knott, 2015; Otgaar & Candel, 2011), that is, without any external suggestive influence, and false memories that emerge as the result of suggestive interviewing techniques (Loftus, 2005). The reason for stressing this distinction is that compared to adults, children are less likely to form spontaneous false memories, but more likely to produce suggestion-induced false memories (Ceci & Bruck, 1993; but see Otgaar, Howe, Brackmann, & Smeets, 2016). Furthermore, stressing this issue is important because spontaneous false memories are more likely to occur because of internal memory mechanisms such as spreading activation whereas suggestion-induced false memories are often the result of a mixture of internal and external factors such as compliance (Otgaar *et al.*, 2016). In child abuse cases, both types of false memories are likely to occur; that is, many of these children have provided statements to different parties, including their parents and friends. The central question here is whether these spontaneous statements are accurate or whether they contain errors of commission (false memories). Furthermore, children are often interviewed by the police or by therapists in forensic settings, and here, there are opportunities for suggestive interviewing techniques that might infect children's statements. In this study, we were interested in maltreated children's susceptibility to both spontaneous *and* suggestion-induced false memories.

Regarding the effects of maltreatment, there are reasons to assume that traumatic events might adversely affect children's memory performance. For example, a history of trauma has been linked to deficits in memory-related brain areas such as reduced hippocampal volume (Carrion, Haas, Garrett, Song, & Reiss, 2009; Carrion, Weems, & Reiss, 2007; but see also De Bellis, Hall, Boring, Frustaci, & Moritz, 2001). Also, children with an abuse experience show more overgeneral memory than neglected or non-maltreated children (Valentino, Toth, & Cicchetti, 2009). Such examples might fuel the idea that trauma negatively impacts children's true memories.

However, there are also studies showing no clear basic memory differences between traumatized and non-traumatized children (Howe, Cicchetti, & Toth, 2006; McWilliams, Harris, & Goodman, 2014). One line of work has focused on the effects of trauma on the formation of children's spontaneous false memories. For example, studies that have employed the Deese–Roediger–McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995) have found limited evidence for differences between maltreated and non-maltreated children's true and false memory rates (Howe, Cicchetti, Toth, & Cerrito, 2004). In the DRM procedure, participants receive associatively related words (e.g., *soda, bitter, pie, heart, good, sugar*) that are linked to a non-presented word labelled as the critical lure (i.e., *sweet*). The standard finding is that participants falsely recollect the critical lure with rates often indistinguishable from rates of true memories (Roediger & McDermott, 1995).

The absence of differences in children's susceptibility to spontaneous false memories also extends to information that is emotional in nature. For instance, Howe, Toth, and Cicchetti (2011) found no differences between maltreated and non-maltreated children's true and false memory rates for negatively valenced word lists. However, other studies did find differences when emotionally charged DRM lists are used. Indeed, using maltreated children whose abuse was so severe that they had been forcibly removed from their biological parents, such children were more likely to produce negative false memories than non-maltreated children; that is, Baugerud, Howe, Magnussen, and Melinder (2016) presented severely maltreated and non-maltreated children (7- to 12-

year-olds) emotionally negative (e.g., critical lures: *violence, dead, scared*) and neutral (e.g., critical lures: *man, bed, flower*) DRM word lists. The results revealed no differences between the two groups of children with regard to the level of false memories elicited by the neutral lists. Interestingly, however, the researchers found that maltreated children reported significantly higher levels of false memories in relation to the emotionally negative lists as compared to non-maltreated children. This shows that maltreatment might increase spontaneous false memories, especially for information that is emotionally negative in nature. Similar results were obtained by Goodman, Quas, and Ogle (2009) who also noted that adolescents and adults with a history of child sexual abuse were more prone to produce emotionally negative false memories than participants without a documented history of child sexual abuse. A potential mechanism that might have caused these effects is that traumatized individuals are especially receptive for emotionally negative stimuli. So, when they are confronted with such stimuli they are likely to make both correct and incorrect associations, ones that result in the creation of false memories.

When we focus on trauma and its effect on children's *suggestion-based* false memories, studies seem to show that maltreatment does not lead to increases or decreases in susceptibility to suggestive pressure in children (Chae, Goodman, Eisen, & Qin, 2011; Eisen, Goodman, Qin, Davis, & Crayton, 2007). Eisen *et al.* (2007), for example, tested susceptibility to suggestive questions in 3- to- 16-year-old maltreated and non-maltreated children who received a physical examination (i.e., body, genital, and anal) to collect medical evidence for signs of child sexual/physical abuse or neglect. After an interval of 4 days, children were interviewed about this examination and received open (e.g., 'What did the nurse look like?') and suggestive ('The nurse didn't put something tight on your arm, did she?') questions. Results basically showed that maltreated children responded in a similar way to the follow-up questions and thus were not found to be either more or less vulnerable to suggestive pressure than control children. This dovetails nicely with other work that also revealed that abuse status did not impact suggestibility levels (Chae *et al.*, 2011).

To recap, although work on maltreated children's false memory formation is still somewhat limited, the picture so far seems to be the following. Severe maltreatment appears to increase children's susceptibility to emotionally negative spontaneous false memories but may not influence their susceptibility to suggestion-based false memories. However, because of this limited evidence, several theoretical and practically relevant issues need to be resolved. First, all of the studies discussed above only focused on one specific type of false memory (spontaneous or suggestion-based), and thus, no research can be found investigating both types within one and the same study. Such an investigation seems crucial because only in this way it can be clarified whether an increase in emotionally negative false memories in maltreated children goes hand in hand with any effects on suggestibility. So, the question is whether in maltreated children, susceptibility to one type of false memory (spontaneous) is related to susceptibility to another type of false memory (suggestion-based).

An examination of spontaneous and suggestion-based false memories in the same maltreated children is even more important because there exists debate about the relationship between different types of false memories and whether these types of false memories share similar underlying mechanisms (Pezdek & Lam, 2007; Wade *et al.*, 2007). Work in this area has produced mixed results with some studies showing no relationship between spontaneous and suggestion-based false memories in children and adults (Ost, Blank, Davies, Jones, Lambert, & Salmon, 2013) and other studies demonstrating a positive link between spontaneous false memories and autobiographical

false memories (Clancy, McNally, Schachter, Lenzenweger, & Pitman, 2002; Otgaar, Verschuere, Meijer, & van Oorsouw, 2012). Importantly, although there might be overlap in the mechanisms underlying spontaneous and suggestion-induced false memories, one fundamental difference is the following. Spontaneous false memories are exclusively the result of endogenous processes such as spreading activation whereas suggestion-induced false memories are caused by a mixture of both endogenous and exogenous processes such as external suggestive interviewing techniques. We will examine both types of false memories in this study. From a forensic perspective, a canonical example is that maltreated children are repeatedly asked to provide statements and are asked many – sometimes suggestive – questions, thereby creating an opportunity for both spontaneous and suggestion-based false memories to occur (Ceci & Bruck, 1993; Howe & Knott, 2015).

In addition, whereas previous studies on false memories in maltreated children have assessed the occurrence of spontaneous false memories by means of a prototypical experimental procedure (i.e., the DRM paradigm), suggestion-based false memories have been measured in a less standardized way. More precisely, in these studies, children were exposed to a variety of events about which quite different suggestive questions were asked. It remains unclear to what extent procedures were effective to elicit suggestion-induced false memories and to study differences between maltreated and non-maltreated children. A reliable and robust way to produce suggestion-based false memories is the misinformation paradigm (Loftus, 2005), which surprisingly has not been employed in previous studies on false memories in maltreated children. In this paradigm, participants are exposed to an event (e.g., a robbery), presented to them either live or on video. After this, they receive misinformation concerning the event (e.g., that the robber was carrying a knife while in fact he had a gun) often in the form of a narrative. Research has demonstrated that many participants incorporate this misinformation into their memory reports, thereby producing false memories (Loftus, 2005).

Another reason for why no differences in false memory propensity for suggestive questions were detected in previous work is because of the samples used in those studies; that is, in earlier studies, maltreated children did not have a history of severe physical/sexual abuse. This is important to consider because Baugerud *et al.* (2016) showed that when the sample included children with more several maltreatment histories, these children evinced higher levels of negative spontaneous false memories. Hence, in this study, we attempted to test children with a more severe abuse history (physical and sexual abuse). Many of these children were involved in legal proceedings, and such cases are only being brought to court when children's accounts refer to serious abusive experiences.

In this study, maltreated and non-maltreated children's false memories were tested using the DRM paradigm and misinformation paradigm. Specifically, we presented children with emotionally negative and neutral DRM word lists. Furthermore, during the misinformation procedure, we presented children with a video concerning a negative event (i.e., robbery). Based on previous work (Baugerud *et al.*, 2016), our predictions were that the maltreated children would evince higher levels of spontaneous false memories especially for emotionally negative words than the non-maltreated children. Based on previous work (Chae *et al.*, 2011), our hypothesis regarding suggestion-induced false memories was that we expected to find that misinformation effects would not differ between maltreated and non-maltreated children. In addition, we also measured levels of intelligence and dissociation as previous work has indicated that these factors might affect children's memory (Chae *et al.*, 2011).

Method

Participants

In the current study, 127 4- to 12-year-old children (maltreated: $n = 21$; mean age = 8.24 years, $SD = 2.28$, range 4–11; non-maltreated: $n = 106$; mean age = 9.44 years, $SD = 1.66$, range 6–12) were tested. Maltreated children were recruited from a forensic child abuse centre ($n = 11$) and a child interrogation studio ($n = 6$), both located in the Netherlands. In the forensic child abuse centre, children were medically evaluated for signs of sexual and physical abuse. Parents of four elementary children (mean age = 9.25, $SD = 0.96$) informed us that their children had a history of child sexual abuse (see also below). These children were included in the maltreated sample leading to a total sample of 21 maltreated children. Referrals to this forensic child abuse centre were from child protection services where the alleged child sexual abuse was reported. Also, some children who were referred to this centre were already involved in legal cases and were brought to the centre by the police. Children who were recruited from the child interrogation centre were all involved in legal cases concerning sexual abuse. Thus, children from both the forensic centre and the child interrogation room were referred to those places because it was suspected that they experienced severe forms of abuse (physical and sexual abuse). Parents or other caretakers had to provide consent before participation. Children were tested at the forensic child abuse centre or at their homes in separate quiet rooms. Twenty-nine per cent ($n = 7$) of the parents reported to have a below average income, and 14% ($n = 3$) reported to have an average or above-average income. We did not receive any information regarding the income of the other parents. Children received a small present for their participation in the study.

The non-maltreated children were recruited from elementary schools in middle-class areas in the Netherlands. The parents of these children also provided parental consent before participation. The schools consisted of children with parents having average income. Children were tested in separate rooms at their school. Similar to the maltreated children, these non-maltreated children received a present for their participation. The study was approved by the ethical committee of the Faculty of Psychology and Neuroscience, Maastricht University.

Materials

Dissociative Experiences Scale for Adolescents

For exploratory reasons, we included the Dissociative Experiences Scale for Adolescents (A-DES; Armstrong, Putnam, Carlson, Libero, & Smith, 1997). The A-DES is a self-report measure of dissociation commonly used for 11-year-old children and older. It contains 30 items describing dissociative experiences ('Something inside of me seems to make me do things that I don't want to do') using 11-point scales (0 = never to 10 = always). The A-DES has high reliability, internal validity, and discriminant validity (Armstrong *et al.*, 1997).

Wechsler Intelligence Scale for Children

We used the third version of the Wechsler Intelligence Scale for Children (WISC) (Wechsler, 1991) to estimate children's level of intelligence. Specifically, the Vocabulary and Block Design subtests were administered, which have high correlations with the

WISC-III full-scale scores. Norm scores were calculated for the present experiment. An estimate of the total IQ was derived using the norm scores of the Vocabulary and Block Design subtests (Wechsler, 1991).

Trauma history

To provide some objective information on children's history of trauma, we presented children's parents or caretakers with an adapted version of the Childhood Trauma Questionnaire-Short Form (CTQ-SF; Bernstein & Fink, 1998; Thombs, Bernstein, Lobbestael, & Arntz, 2009). The CTQ-SF is a 28-item self-report questionnaire that measures multiple dimensions of childhood maltreatment: Physical abuse, emotional abuse, sexual abuse, physical neglect, emotional neglect, and minimization/denial. Each dimension contains five items except the minimization/denial scale that comprises three items. Items are scored from 1 (never true) to 5 (very often true). Originally, the CTQ-SF is a self-report questionnaire, but for the purpose of this study, items were rephrased from the perspective of the child. Thus, an item of the original version such as: 'When I was growing up, I didn't have enough to eat' was changed into 'When (s)he was growing up, (s)he didn't have enough to eat'.

DRM paradigm

We used five neutral (critical lures: *bread, smoke, window, foot, sweet*) and five negative (critical lures: *murder, punishment, cry, death, pain*) 10-word DRM lists in this experiment. An example of a negative DRM list was as follows: tears, sorrow, laugh, whine, baby, scream, roar, whining, wet, weep, which referred to the critical lure 'cry'. These DRM lists have been used in previous research and are effective in generating spontaneous false memories (Otgaar *et al.*, 2016). The DRM recognition task contained 78 words including 40 correct items (e.g., butter, tears), 10 critical lures, 10 non-presented related items (e.g., deceased, syrup), and 18 non-presented unrelated items (e.g., rock, bus). The recognition task was audiotaped and was presented at a rate of 5-second per item. We calculated hit rates (correct responses divided by total possible correct items [=40]) and false alarm rates (e.g., for critical lures: false responses divided by total number of critical lures [=10]).

Misinformation paradigm

We presented children with a negatively laden video of a bank robbery. This video had already been successfully used in previous research (Otgaar *et al.*, 2016). Misinformation was presented in the form of an eyewitness account, which was audiotaped and presented to the children. In the account, the eyewitness suggested five incorrect details that were not shown in the video (i.e., pistol, money, laptop, brochures, ticket-dispenser) and 20 correct details that were really presented during the video. The recognition task was composed of 50 items consisting of the five incorrect details and 20 correct details, five related but not-presented items, and 20 unrelated but not-presented items. Items were presented at a 5-second rate, and responses were recorded by the experimenter. We calculated hit rates (correct responses divided by total possible correct items [=20]) and false alarm rates (e.g., for incorrect items: false responses divided by total number of critical lures [=5]).

Design and procedure

This study involved a between-subjects design with maltreated versus non-maltreated children as our independent variable. For the DRM paradigm, we also had a within-subjects factor in that children received both negative and neutral DRM lists. The order of the lists was counterbalanced. Furthermore, it was also counterbalanced whether children first received the DRM paradigm or the misinformation paradigm.

After parents/caretakers provided consent, they were given the adapted version of the CTQ-SF. During the DRM procedure, children listened to the word lists which were presented to them by means of a headphone. After the presentation of the lists, a 3-minute filler task was provided to the children (i.e., find the differences). Then, the recognition task of the DRM task was administered. During the misinformation paradigm, children were first presented with the video, which was displayed by means of a laptop using headphones for sound. Following this, there was again a 3-minute filler task (Find the differences), after which children received the misinformation by listening to the eyewitness account via headphone. Next, children engaged in a third and final 3-minute filler task (Find the Differences). After this, children received the recognition task of the video. Subsequently, children had to fill in the A-DES. When children did not (fully) understand certain items of this questionnaire, the experimenter gave them additional explanation. This was especially relevant for younger children as the A-DES is originally designed for children aged 11 years and above. After the extra clarification, all children were able to complete the A-DES (with or without help of the experimenter). Finally, children were presented with the Vocabulary and Block Design subtests of the WISC.

Results

Preliminary analysis

To obtain a more objective estimate of the maltreatment status of our sample, we first examined the scores on the CTQ-SF between the maltreated and non-maltreated children. As expected, using independent-samples *t*-tests, on all scales, except for emotional and physical neglect, parents/caretakers of maltreated children provided higher trauma-related scores than the parents/caregivers of non-maltreated children (Table 1). We also examined whether IQ scores differed between the two groups. Although the IQ scores of children in both groups fell within the average range, an independent-samples *t*-test showed that the mean IQ score was statistically higher for children in the non-maltreated group (M = 109.11, SD = 12.65) than for those in the maltreated group, M = 92.61, SD = 14.80, $t(124) = 5.21$, $p < .001$, Cohen's d = 1.20.

DRM task

Hit rates

As dissociation and intelligence have been shown to affect children's memory (Chae *et al.*, 2011), they were included as covariates in our statistical analyses. Also, because the age range was quite broad in our sample, we incorporated age as a covariate as well. As is customary in developmental research on (spontaneous) false memories, scores were corrected for possible response bias, a correction that leads to purer measures of hits and false memory (Otgaar *et al.*, 2016). To be more precise, scores were transformed using the following two-high threshold correction (H − FA(U)) in which H is the hit rate for presented items and FA(U) refers to false alarms of non-presented unrelated items

Table 1. Childhood Trauma Questionnaire scores between the maltreated and non-maltreated group

	Group	Mean (*SD*)	*p*-value	Cohen's *d*
Emotional abuse	Non-maltreated	6.28 (1.71)	<.001	1.20
	Maltreated	10.62 (4.80)		
Physical abuse	Non-maltreated	5.34 (1.01)	<.001	0.78
	Maltreated	7.33 (3.44)		
Sexual abuse	Non-maltreated	5.10 (0.37)	<.001	0.92
	Maltreated	9.50 (6.73)		
Emotional neglect	Non-maltreated	8.78 (3.50)	.42	0.19
	Maltreated	9.50 (4.22)		
Physical neglect	Non-maltreated	6.21 (1.82)	.16	0.32
	Maltreated	6.86 (2.26)		
Minimization	Non-maltreated	3.00 (.00)	<.001	5.16
	Maltreated	0.41 (.71)		

Note. Except for minimization, higher scores indicate higher levels of trauma.

(Snodgrass & Corwin, 1988). False alarms for critical items were also transformed using (FA(CL) − FA(U)) where FA(CL) refers to false alarms for critical items. Finally, we corrected false alarms for related items using (FA(R) − FA(U)) where FA(R) is the false alarm rate for non-presented related items. This correction was applied for memory types of both the DRM and misinformation paradigms.

A 2 (Group: maltreated vs. non-maltreated) × 2 (Emotion: negative vs. neutral) ANCOVA with the last factor being a repeated measure was conducted on the corrected hit rates (Table 2). This was done to examine the effects of trauma on correct recognition. The covariates dissociation and intelligence scores did not have statistical effects on the hit rates (*p*s > .05). Age as a covariate did have a statistical effect on hit rates ($p < .001$) with children having higher scores when getting older. Neither the main effects of Group, $F(1, 118) = 1.39$, $p = .24$, $\eta_p^2 = .01$, and Emotion, $F(1, 118) = 0.01$, $p = .92$, $\eta_p^2 = .00$,

Table 2. DRM-corrected memory scores in maltreated and non-maltreated children

	Group	Mean (*SD*)
Hit rates neutral	Non-maltreated	.39 (.23)
	Maltreated	.28 (.28)
Hit rates negative	Non-maltreated	.49 (.21)
	Maltreated	.37 (.25)
Critical lures neutral	Non-maltreated	.38 (.29)
	Maltreated	.28 (.35)
Critical lures negative	Non-maltreated	.51 (.25)
	Maltreated	.38 (.30)
Related items neutral	Non-maltreated	−.06 (.16)
	Maltreated	−.13 (.22)
Related items negative	Non-maltreated	.03 (.16)
	Maltreated	.14 (.20)

Note. Because these scores are corrected, values can become negative.

nor the interaction of Group and Emotion attained statistical significance, $F(1, 118) = 0.00, p = .97, \eta_p^2 = .00$.

False memories (spontaneous)

When we conducted a repeated-measures ANCOVA on the corrected false memory scores for the critical lures, no statistical effects emerged (*p*s > .12). However, when we focused on false memories for related items, we found a statistically significant interaction, $F(1, 118) = 14.43, p < .001, \eta_p^2 = .11$. As predicted, there were no differences for the neutral lists ($p = .07$), but simple effects analyses for the negative lists showed that maltreated children ($M = .14$, $SD = .20$) evinced higher levels of spontaneous false memories than non-maltreated children ($M = .03, SD = .16. p = .02$; Table 2). A Bayesian analysis identified a Bayes factor (BF; 10) of 4.70, indicating more evidence for the alternative (more negative false memories in maltreated than in non-maltreated children) than the null hypothesis. In this analysis, none of the covariates was statistically significant (all *p*s > .05).

Misinformation task

Hit rates

Because the assumption of homogeneity of variances was violated, the data were analysed using a Mann–Whitney *U*-test. Our analysis showed that maltreated children (mean rank = 36.58) had statistically lower hit rates than non-maltreated children (mean rank = 68.58; $U = 521.50, z = -3.62, p < .001, r = -.32$). A BF (10) > 1,000 was found.

False memories (suggestion-induced)

A similar analysis showed that suggestion-induced false memories were less likely to emerge in maltreated (mean rank = 48.75) than in non-maltreated children (mean rank = 66.28; $U = 765.00, z = -2.02, p = .04, r = -.18$; Figure 1). We also found a BF (10) of 717.80. We also looked at false alarms for related items. For this analysis, the homogeneity of variances assumption was not violated. Using an ANCOVA with dissociation, intelligence, and age as covariates, we found a main effect of Group, $F(1, 119) = 4.27, p = .04, \eta_p^2 = .04$. Like our suggestion-induced false memory data, we found that false memory levels for related items were statistically lower in the maltreated ($M = 0.10$, $SD = 0.14$) than in the non-maltreated children ($M = 0.16$, $SD = 0.14$; see Table 3 for the corrected scores). A BF (10) of 3.66 was detected. The covariates were not statistically significant (*p*s > .15).

Exploratory analyses

Although we controlled for age in all our analyses where possible, two issues in our data need extra attention. First, the mean age between the maltreated and non-maltreated differed statistically from each other, $t(125) = 2.85, p = .005$, Cohen's $d = .60$. Second, we tested far more control ($n = 106$) than maltreated children ($n = 21$). To deal with these issues, we *explored* the effects of maltreatment on false memory by comparing our maltreated sample with a non-maltreated sample that was matched by age. This was done by excluding children aged 9 or older from the non-maltreated sample. This resulted in a

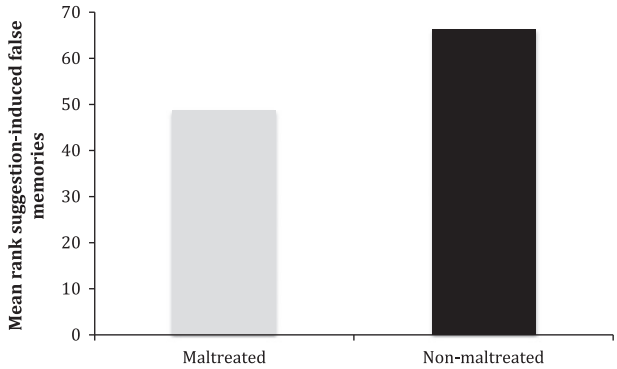

Figure 1. Mean rank suggestion-induced false memories as a function of maltreatment.

Table 3. Corrected scores (means and standard deviations) of the misinformation task for children in the maltreated and non-maltreated group

	Maltreated	Non-maltreated
Hit rates	0.45 (0.30)	0.68 (0.12)
False memory	0.47 (0.38)	0.67 (0.24)
False memory for related items	0.07 (0.16)	0.16 (0.14)

non-maltreated sample consisting of 38 children (mean age = 7.55, SD = 0.55), which importantly no longer statistically differed from the maltreated children in terms of age, $t(57) = -1.77$, $p = .082$, Cohen's $d = .42$.

When we focused on the impact of maltreatment on DRM false memories for critical lures, we only found that negative false recall ($M = 0.37$, $SD = 0.26$) was statistically higher than neutral false recall, $M = 0.21$, $SD = 0.30$; $F(1, 55) = 9.34$, $p = .003$, $\eta_p^2 = .15$. In line with what we found earlier, for the related items, we found that only the negative false memories were statistically higher in the maltreated ($M = 0.12$, $SD = 0.20$) than in non-maltreated children, $M = 0.00$, $SD = 0.17$; $F(1, 55) = 7.16$, $p = .010$, $\eta_p^2 = .12$. Regarding the misinformation false memories, we found false memory levels again to be lower in maltreated ($M = 0.47$, $SD = 0.38$) than in non-maltreated children, $M = 0.61$, $SD = 0.21$; $t(56) = 1.89$, $p = .06$, Cohen's $d = .46$, albeit that this difference was not staistically significant. Further, we found that maltreated children ($M = 0.07$, $SD = 0.16$) had statistically lower false memory rates for related items than non-maltreated children, $M = 0.18$, $SD = 0.16$; $t(56) = 2.44$, $p = .02$, Cohen's $d = .69$.

We also explored whether spontaneous false memories were related to suggestion-induced false memories. However, we did not find any significant correlations between these two types of false memories (all ps > .21).

Discussion

We were interested in the effects of maltreatment on children's spontaneous *and* suggestion-induced false memories. The results of the current study can be catalogued as follows. For spontaneous false memories, we found that maltreatment was associated with higher rates of negative false memories for related items. However, for

false memories induced by misinformation, the reverse was true. Here, we found that maltreated children were less susceptible to suggestion-based false memories than non-maltreated children. To our knowledge, this study represents the first empirical attempt to examine maltreatment effects on different types of children's false memories.

Our finding that negative spontaneous false memories for related items were more easily evoked in maltreated than in non-maltreated children is in line with some of the earlier work on this topic (Baugerud *et al.*, 2016; Goodman *et al.*, 2009). Those studies also showed that maltreatment was associated with higher false memory rates for negative DRM lists. The reason for the increased rates of negative false memories in (severely) maltreated children may have to do with the fact that such children are particularly sensitive and responsive to emotional stimuli; that is, maltreated children are often exposed to multiple and chronic forms of abuse that might deteriorate their general memory performance and the way they handle emotional experiences (Beers & De Bellis, 2002). Studies have shown that maltreated children have problems with emotion regulation and display increased arousal levels (Kim & Cicchetti, 2009). As studies show that false memories increase as arousal levels become elevated (Howe, Toth, & Cicchetti, 2006), maltreated children might be more prone to automatically activate related but non-presented negative information in memory during encoding. In addition, these children might be subject to more failures in monitoring differences between negative true and false information during retrieval, something that would also lead to heightened spontaneous false memory levels.

It must be said that these former studies found that maltreatment affected false memories for critical lures (Baugerud *et al.*, 2016), whereas our study only found support for maltreatment effects on false memories for related items. Of course, although our findings are to some extent consistent with earlier work, our study and the previous ones differ on some critical points. To begin with, in the study by Baugerud and colleagues, recall measures were used whereas we assessed recognition. It is especially important when studying the effects of emotion on false memories, that the method used to measure memory (recall or recognition) is taken into account; that is, studies have shown mixed effects depending on whether recall or recognition tests are used (Howe, Candel, Otgaar, Malone, & Wimmer, 2010). For example, research generally shows that false recall is frequently higher for neutral than for negative lists, whereas the opposite is found when using recognition tests. Furthermore, in the maltreated sample in Baugerud *et al.*'s study, children had been subjected to a mixture of different types of abuse such as physical/sexual abuse *and* neglect. In our study, sexual abuse was most likely to have played a role, while there was no obvious evidence for issues of neglect. This is important because research suggests that different types of trauma might have differential effects on memory (Chae *et al.*, 2011). It is certainly possible that both the use of different memory measures and somewhat different trauma samples might have contributed to the slightly different false memory outcomes between Baugerud *et al.*'s study and the present investigation. Furthermore, research in the area of the effects of trauma on false memory is still scarce and so far results have been quite inconsistent; that is, some studies have not found trauma to impact (negative) spontaneous false memories (Howe *et al.*, 2004, 2011) while others have found trauma to affect (negative) spontaneous false memories (Baugerud *et al.*, 2016; Goodman, Ogle, Block, & Harris, 2011). These different results could be due to a variety of reasons, such as the use of different DRM lists or sample characteristics (i.e., adolescents and adults vs. children; Goodman *et al.*, 2011). All in all, the fact that we did not find trauma to effect false

memory for critical lures is not a completely out of line with prior research. What it does suggest is that considerably more research needs to conducted in order to better specify the effects of trauma on children's true and false memory.

Contrary to our expectations, we found that maltreated children were less prone to accept suggestive information than non-maltreated children. We found this result for both false alarms and related items. This is a hitherto unreported finding. Previous work has found that maltreated and non-maltreated children did not differ with respect to their levels of suggestibility (Eisen *et al.*, 2007). It is unclear why the present results deviate from those obtained in previous work. However, it must be emphasized that our study was the first to employ a standardized way (i.e., misinformation paradigm) to elicit suggestion-induced false memories. In previous research, children were involved in different events and received different questions by different experimenters. However, we used a well-controlled and often-used procedure (i.e., the misinformation paradigm; Loftus, 2005) to foster suggestion-induced false memories in children.

Furthermore, the reason for decreased misinformation effects in maltreated children might be that these children also had lower hit rates than non-maltreated children. This is relevant because the incorrect details (e.g., pistol) that were mentioned in the eyewitness testimony were associatively related to the details presented in the video (e.g., robber). There is a wealth of studies showing that false memories are caused by associative activation (Howe, Wimmer, Gagnon, & Plumpton, 2009; Otgaar *et al.*, 2016). Because maltreated children had lower hit rates in the misinformation task than non-maltreated children, there were fewer opportunities to associatively activate related, but false, details, thereby leading to reduced suggestion-induced false memory effects in maltreated children. It should be stressed here that the lower hit rates of maltreated children were only evident in the misinformation task and not in the DRM task. Hence, our reasoning that maltreated children were less able to automatically activate related details than non-maltreated children only applies to our findings of the misinformation task and does not imply that traumatized children have a general deficit in using spreading activation. Of course, future studies should attempt to replicate this finding and examine whether standardized methods to induce suggestion-induced false memories might indeed lead to reduced false memories in maltreated children. Attempting to replicate this finding is all the more relevant because when our data were matched by age, we only found on a descriptive level that misinformation effects were lower in the maltreated than non-maltreated children ($p = .06$).

Our study is the first to have combined procedures to elicit both spontaneous *and* suggestion-induced false memories. Previous work in this field has only focused on one type of false memory or did not use the standard experimental procedure used to elicit these different false memories. For example, in Chae *et al.*'s (2011) and Eisen *et al.*'s (2007) studies, children's susceptibility to suggestive questions was examined, but also commission errors to non-suggestive questions were measured. One might posit that the latter category could be regarded as a form of spontaneous false memory. The crucial problem with this interpretation is that it is not clear whether these commission errors reflect responses purely based on 'memory' or whether they reflect a response bias (Brainerd, Reyna, & Ceci, 2008). Therefore, the DRM procedure is frequently employed because it has been specifically designed to tap into memory mechanisms, such as spreading activation, that might result in the creation of spontaneous false memories.

There are also some caveats of the present study that need to be discussed. First of all, our non-maltreated sample was much larger and on average somewhat older than the maltreated sample. To deal with these issues, we controlled for age in our analyses and also

conducted an additional analysis in which we made an attempt to match maltreated and non-maltreated children. On both occasions, we found evidence to suggest that maltreatment increased negative spontaneous false memories, but decreased suggestion-induced false memories. Still, future research in this area would benefit from including more matched groups of maltreated and non-maltreated children.

Second, our conclusions might be seen as tentative because of the small sample size of maltreated children. Related to this is that our maltreated group mainly consisted of children being referred to child interrogation rooms or a forensic child abuse centre. Such children are only referred to such places if there are serious indications for severe physical and sexual abuse. Of course, a recurrent shortcoming in studies like ours is that the abusive claims are not substantiated. Third, in the current study, we sometimes had to use materials unsuitable for young children (A-DES, WISC).[1] This is particularly true for the A-DES, which is normally used in children aged 11 and above and thus may contain items that were not fully understood by the young participants in our sample. But is also applies to the WISC, which has a lower age limit of 6 years, although the subtests Block Design and Vocabulary are included in the preschool version of this test (Wechsler, 1989). Of course, prospective work in this area should include developmentally appropriate measures. Fourth, one might argue that our results have limited practical value because our experiment focused on recognition measures. However, in DRM research, although it is true that for some findings (e.g., the effect of emotion on false memory) recall and recognition results can differ, for other findings (e.g., developmental increases in false memories) the results are the same for recall and recognition (Brainerd *et al.*, 2008). Furthermore, in legal contexts, it is known that children are often not asked open-ended recall questions, but are interviewed using closed questions such as the ones we used in our recognition tasks (e.g., 'Do you remember that your father touched you on your buttocks?'). Also, our results might have limited generalizability because our memory test was done in one test session while children in legal cases are often asked about their memories after long delays. However, one might still expect that when longer delays are used that our results would still hold. The reasoning behind this is that memory performance deteriorates after passage of time and that people tend to rely more on meaning when remembering, making false memories more likely to occur. Furthermore, research shows that emotionally negative false memories are more likely to occur after a delay (Howe *et al.*, 2010) which would mean that, especially for maltreated children, negative false memories are more likely to arise after the passage of time.

Another possible limitation is that our differences in eliciting spontaneous and suggestion-induced false memories between maltreated and non-maltreated children (i.e., increases and decreases in false memory) are an artefact of the type of procedure that was used. Of course, our tasks used to induce false memories were quite different from each other and so, ideally the same material should be used to elicit both types of false memories. For example, word lists were used to elicit spontaneous false memories while a video and misinformation was used to elicit suggestion-induced false memories. So, one

[1] *The A-DES and the WISC are not suitable for use with very young children such as 4- or 5-year-olds. However, the forensic child abuse institute only approved that we used the materials as included in the present study and hence, other materials could not be added. To circumvent this issue, we made sure that when young children received the A-DES or the WISC, the research assistant sat next to the children to explain the items of the tests and assist them in completing these measures. For example, for the A-DES, after each item, children were asked before the rating whether they understood the item. If not, the research assistant explained the item, after which they were asked once more if they understood the item. If they did not, they did not complete the rating for that particular item.*

could argue that our results merely show that maltreated children are less likely to form negative false memories for *word lists* than non-maltreated children whereas this difference changes when procedures (e.g., misinformation paradigm) involving more emotionally arousing and complex life events are employed. However, this argument falls short for the following reasons. First, research has shown that emotional word lists such as the ones used in the DRM paradigm evoke emotional reactions that are quite similar to the ones produced by complex real-life events and autobiographical memories (Rubin & Talarico, 2009). Second, although there is debate about whether different false memories share similar underlying mechanisms (Ost *et al.*, 2013; Otgaar & Candel, 2011), there is some evidence showing that DRM false memories are positively related to (false) autobiographical memories (Clancy *et al.*, 2002). However, in the current study, we did not find evidence for a relationship between suggestion-induced false memories and spontaneous false memories which implies different mechanisms probably underlie these different types of false memories. The implication of this could be that laboratory tasks that induce false memories are not likely to be directly generalized to false memories occurring in daily life (e.g., during suggestive police interviews). Nonetheless, apart from the question about whether different false memories share similar mechanisms, in the legal arena, spontaneous false memories and suggestion-induced false memories are both relevant. Children involved in legal proceedings oftentimes provide testimony spontaneously while also being asked (suggestive) questions by interviewers (BLINDED). As the DRM and misinformation paradigms have been constructed to mimic such situations, our findings could be of definite legal relevance.

To recap, in the present study, we examined the effects of maltreatment on children's spontaneous and suggestion-induced false memories. Our study extends previous work related to the debate on the effects of trauma on memory. Our new angle in this debate is that our results suggest that trauma does affect memory, but in a rather complex and unique way. Although there is research showing that trauma does not impact memory functioning (McWilliams *et al.*, 2014), we found that maltreated children were more susceptible to negative false memories than non-maltreated children. In contrast, we also showed that misinformation effects were less pronounced in maltreated than in non-maltreated children. This study shows that maltreatment might have varying complex effects on false memories depending on their type (spontaneous vs. suggested) adding to the accumulating evidence that the effects of maltreatment on memory can be both positive and negative.

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