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Eliminating Age Differences in Children's and Adults' Suggestibility and Memory Conformity Effects

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Abstract

We examined whether typical developmental trends in suggestion-induced false memories (i.e., age-related decrease) could be changed. Using theoretical principles from the spontaneous false memory field, we adapted two often-used false memory procedures: misinformation (Experiment 1) and memory conformity (Experiment 2). In Experiment 1, 7/9-year old children (*n* = 33) and adults (*n* = 39) received stories containing associatively-related details. They then listened to misinformation in the form of short narrative preserving the meaning of the story. Children and adults were equally susceptible to the misinformation effect. In Experiment 2, younger (7/8-year-olds, *n* = 30) and older (11/12-year-olds, *n* = 30) children and adults (*n* = 30) viewed pictures containing associatively-related details. They viewed these pictures in pairs. Although the pictures differed, participants believed they had viewed the same pictures. Participants had to report what they could recollect during collaborative and individual recall tests. Children and adults were equally susceptible to memory conformity effects. When correcting for response bias, adults' false memory scores were even higher than children's. Our results show that age trends in suggestion-induced false memories are not developmentally invariant.

Keywords: False Memory; Developmental Reversal; Development; Misinformation; Memory Conformity

Eliminating Age Differences in Children's and Adults' Suggestibility and Memory Conformity Effects

In court, it is generally assumed that children are more likely to fall prey to suggestive pressure and false memory formation than adults (e.g., Brackmann, Otgaar, Sauerland, & Jelicic, in press; Bruck & Ceci, 1999). Consistent with this assumption, research on *suggestion-induced* false memories (where witnesses receive incorrect information about an experienced event) shows that although both children and adults are susceptible to these memory illusions, children tend to be more susceptible than adults (Bruck & Ceci, 1999). However, these developmental trends are reversed when *spontaneously-induced*[1] false memories are examined (Howe, Wimmer, Gagnon, & Plumpton, 2009). Specifically, one of most frequently used methods to elicit spontaneously-induced false memories is by using the Deese/Roediger-McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995) where participants receive word lists containing associatively-related concepts (e.g., *hill, summit, Alps*). In this paradigm, both children and adults not only remember some of the presented words but they also falsely remember other non-presented, associatively related theme words (i.e., the critical lure, *mountain*). Importantly, adults are more susceptible to these spontaneous memory illusions than children (Howe et al., 2009).

In the current experiments, we examined developmental trends in two paradigms frequently used to induce suggestion-induced false memories: misinformation (Experiment 1) and memory conformity (Experiment 2). Our main interest was to see whether we could reverse or at least attenuate developmental trends in suggestion-induced false memories to levels akin to the developmental reversals observed with spontaneous false memories (e.g., age-related increase rather than decrease). Suggestion-induced false memories frequently occur in the misinformation paradigm. Here, participants experience an event (e.g., witness a staged-crime) and are then presented with misinformation about that event in which a number of false details are suggested (e.g., that the robber used a gun) as having been present in the witnessed event. Typically, a significant minority of participants accept the misinformation as being part of the original event (a false memory) and this misinformation effect is more prevalent in younger than in older children and adults (Otgaar, Candel, Smeets, & Merckelbach, 2010; Sutherland & Hayne, 2001).

In the memory conformity paradigm pairs of participants view two slightly different versions of an event but are under the impression that they are viewing the same event. They then engage in an interactive discussion about what they have seen during the event. Studies using this procedure demonstrate that participants report having seen information that was mentioned by the co-witness but that was not actually in the event they themselves witnessed. Developmental work on memory conformity effects have produced results that are somewhat mixed. For example, Candel, Memon, and Al-Harazi (2007) compared conformity effects in 7/8- and 11/12-year-olds and found an age-related increase in memory errors for free recall but an age-related decrease for cued recall. Other research has found only limited support for age-related changes in the memory conformity effect (McGuire, London, & Wright, 2011, 2015). However, in these latter studies, 11- to 21-year-olds were tested and age differences in false memories are not always found in this age range (Brainerd, Reyna, & Ceci, 2008; Howe et al., 2009; Otgaar, Howe, Brackmann, & Smeets, 2016).

Explanations concerning developmental differences in false memories include Fuzzy-trace Theory (FTT; Brainerd et al., 2008) and Associative-activation Theory (AAT; Howe et al., 2009; Otgaar, Howe, Peters, Smeets, & Moritz, 2014). FTT suggests that false memories occur when people rely on the underlying meaning of an event. As the ability to extract meaning improves with age, FTT predicts that false memories should increase with age. Alternatively, AAT posits that false memories arise because of the spread of associative activation among related concepts that were not experienced. Because the structure and content of one's knowledge base changes with age, activation will spread faster and more automatically across development in childhood. Like FTT, AAT predicts that false memories increase with age. Furthermore, AAT states that because children's knowledge base is less well-developed than that of adults', they will benefit to a greater extent from stimuli that contain obvious themes such as pictures (e.g., of a beach). That is, when such stimuli are presented – as the current experiments have done – children can more easily extract meaning of such stimuli thereby rivaling false memory rates of adults.

We recently established that the standard developmental trend (i.e., age-related decrease) in suggestion-induced false memories can change when relying on meaning-based manipulations derived from AAT and FTT (Otgaar et al., 2016). In four experiments, we showed that when participants receive associatively-related stimuli and are then exposed to suggestive information that preserves the meaning of the event, susceptibility to misinformation increased, not decreased, with age. This finding seems counterintuitive, as the majority of research on developmental misinformation research has revealed that younger children are more susceptible to suggestion-based false memories than older children and adults. Our previous research suggests that if we adapt the misinformation procedure in a more meaning-based procedure, the standard false memory trend (i.e., age-related decrease) will change. Also, in most forensic cases where misinformation has been suggested to witnesses, these suggestions contain meaning-related details that did not actually occur in the original event. Therefore, our findings are not only critical theoretically, but from an applied perspective, it is important to acknowledge that age is perhaps not the best predictor when evaluating witness' susceptibility to suggestive pressure and the formation of false memories.

Although probative, these findings are somewhat limited as they are confined to one false memory procedure. Indeed, there is considerable debate about whether different false memory procedures elicit the same type of false memory (Wade et al., 2007). Therefore, in order to provide a more convincing case that age differences in suggestion-induced memory illusions are not developmentally invariant, we need to show that trends in false memories can be attenuated or reversed across a variety of different misinformation procedures. The current experiments will do just that, making these developmental false memory findings more domain-general. Put simply, in order to demonstrate that the malleability of development trends in suggestion-induced false memory is not paradigm-dependent, we need to assess the generalizability of these effects across different suggestibility paradigms.

The Current Experiments

To do this, we present two experiments using different false memory paradigms that are frequently employed in memory research and in which false memories are induced via suggestion (Loftus, 2005; Wright, Memon, Skagerberg, & Gabbert, 2009). Specifically, we adapted the misinformation (Experiment 1) and memory conformity (Experiment 2) paradigms so that they paralleled the meaning-based manipulations found in spontaneous false memory paradigms. The general prediction across experiments was that when participants receive associatively-related (mis)information, these related, non-presented details will be falsely remembered. Moreover, the standard developmental trend in suggestion-induced false memories will be reversed or at least, attenuated.

Experiment 1: DRM Stories and Suggestibility Effects

Recent research has shown that when DRM lists are embedded in stories they can easily give rise to false memories (Howe & Wilkinson, 2011; Otgaar et al., 2014). Because younger children's associative networks are less well developed and more poorly integrated than older children's and adults', younger children should particularly benefit from material containing an obvious theme (stories), something which in turn, should give rise to more false memories. Indeed, studies using DRM-based stories have found that developmental reversal effects become attenuated (Howe & Wilkinson, 2011) or even reversed (Otgaar et al., 2014). Therefore, in Experiment 1, we presented children and adults with DRM stories and then suggested that a related item (i.e., the critical lure) also had been present. One would expect that providing suggestions about information that is consistent with a now more obvious story theme should increase misinformation acceptance rates in younger children. If true, then typical developmental trends in suggestion-induced false memories (i.e., age-related decrease) should be attenuated or perhaps even reversed.

A subsidiary aim of Experiment 1 was to examine the role of emotion on the development of suggestion-induced false memories. Although reversal effects have appeared for both neutral and emotionally negative false memories (e.g., Howe, Candel, Otgaar, Malone, & Wimmer, 2010), there is evidence showing that negative suggestion-induced false memories are more likely to show reversal effects than neutral suggestion-induced false memories (e.g., Otgaar et al., 2016). Thus, we used stories that varied in emotion such that some were neutral and others negative.

Method

Before Experiment 1 could be conducted, we needed to pilot the DRM stories and show that children were less likely to grasp the meaning of the stories than adults. In this experiment, 40 7/9-year-olds (mean age = 7.75, *SD* = .63, range: 7-9), 49 10/12-year-olds (mean age = 10.71, *SD* = .54, range: 10-12), and 40 adults (mean age = 21.13, *SD* = 2.19, range: 18-27) were presented with either 6 DRM lists or the same stimuli converted into 6 stories (see below for detailed information about the materials). After the presentation of these stimuli, participants received a recognition including presented and non-presented (critical lure) items. We found a significant main effect of age ($F(2, 123) = 19.41$, $p < .001$, $\eta^2_{partial} = .24$) with younger children (*M* = .39, *SD* = .33; List: *M* = .36, 95% CI [.26 - .49]; Story: *M* = .41, 95% CI [.30 - .52]) falsely remembering statistically fewer items than the older children (*M* = .69, *SD* = .21; List: *M* = .67, 95% CI [.57 - .77]; Story: *M* = .72, 95% CI [.62 - .83]) and adults (*M* = .70, *SD* = .22; List: *M* = .70, 95% CI [.59 - .81]; Story: *M* = .70, 95% CI [.58 - .81]) thereby demonstrating a developmental reversal effect for both lists and stories. No statistically significant Age x Stimulus (List vs Story) interaction was found ($F(2, 123) = 0.17$, $p = .84$, $\eta^2_{partial} = .003$).

Participants

Thirty-three 7/9-year-olds and 39 adults participated in this experiment. One child was omitted because she turned out to be 6 years old, leaving the final sample consisting of 32 7/9-year-olds (mean age = 7.53, *SD* = 0.62; range: 7-9) and 39 adults (mean age = 20.67, *SD* = 1.26; range: 19–24). An à-priori power analysis with a power of 0.80 and a medium effect size (f = 0.375; $\eta^2_{partial}$ = 0.13) resulted in a sample size of 68 (Faul, Erdfelder, Lang, & Buchner, 2007). We stopped with data collection after testing a total of 72 participants in case of potential dropouts. All children had parental consent and assented on the day of testing. Adult participants were undergraduates from the Faculty of Psychology and Neuroscience, Maastricht University.

They received a financial compensation (7.50 euro) or course credits for their participation. The experiment was approved by the standing ethical committee of the Faculty of Psychology and Neuroscience, Maastricht University.

Design

A 2 (Age: 7/9-year-olds vs. adults) x 2 (Emotion: neutral vs. negative) split-plot design was used in this experiment. Participants received two neutral and two negative stories with the order of presentation counterbalanced across participants.

Materials and Procedure

Four DRM lists (2 neutral: *bread, foot;* 2 negative: *pain, cry*) were drawn from a larger pool (see Howe et al., 2010) and have been used in previous false memory research (e.g., Howe et al., 2010; Otgaar, Peters, & Howe, 2012). Each list consisted of 10 words selected from the Dutch word association norms (Van Loon-Vervoorn & Van Bekkum, 1991). Using the CELEX lexical database, we made sure that the mean word frequency of the neutral and emotional critical lures did not differ ($t(8) = 0.22$, $p > .05$). Also, the mean backward associative strength (BAS) between the neutral words and their critical lures and the mean BAS between the emotional words and their critical lures did not differ ($t(8) = 1.69$, $p > .05$). The DRM words were embedded in a story. Story length was roughly the same across stories (range: 119-151 words). Here is an English translated example of a Dutch DRM story using the "*bread*" critical lure (DRM words are underlined):

"'Big' Bertha was the daughter of the <u>baker</u>. Her name was actually just Bertha, but because she loved <u>butter</u> and sweet <u>fillings</u>, she became a bit bigger in weight. Her mouth was often <u>brown</u> from chocolate. Her classmates gave her that nickname and she did not care. She was proud of the profession of her father. In the morning, she looked with interest how he made dough. He told her how you make flour from wheat. Using a knife, he often cut a piece for her. He asked her if she could taste the type of grain. Bertha was sure that she wanted to become like her father when she got older."

We used the standard misinformation procedure containing an encoding phase, misinformation phase, and a memory test (Loftus, 2005). Participants were told that they had to listen and pay attention to some stories. They were then presented with two stories. The stories were audio-recorded. After the presentation of two of the stories, participants heard some misinformation about those stories. Participants then heard another two stories and afterwards received suggestive pressure in the form of misinformation about those two stories. The misinformation was also audio-recorded. Misinformation consisted of a short narrative about someone who presumably also heard the two stories. In the narrative for each story, 4 of the originally presented items and 1 misinformed item (the critical lure) were mentioned. There were two misinformation versions, one for neutral stories (*bread*, *foot*) and one for negative stories (*pain*, *cry*). The order of stories (neutral vs. negative) was counterbalanced. Here is an example of a neutral story where misinformation occurred after the presentation of two stories (the words in bold represent the misinformation of the critical lures):

"I have just heard a story about the daughter of a baker. She really liked **bread.** She is fond of sweet fillings. Early in the morning she saw how her father made dough. She really liked this and when she was old enough, she also wanted to do this. The second story was about Gertje. I remember that he was running in the gym. His toe was hurting. He pulled off his shoe to look at his **foot**. Then, he accidently hurt his leg and ankle."

After all stories were presented, a short distractor task was implemented that lasted 5 minutes (playing Tetris). Finally, a 33-word recognition task was presented containing 16 of the presented items (4 from each story), 4 critical lures (1 from each story), 4 non-presented related items, and 9 unrelated items. Here, participants were asked whether they recognized (or did not recognize) words that were presented during the presentation of the original stories.

Results and Discussion

To eliminate possible age-related response biases, we transformed our scores using the two-high threshold correction (*H - FA(U))* where *H* is the hit rate for presented items and *FA(U)* refers to false alarms of non-presented unrelated items (Snodgrass & Corwin, 1988). False alarms for critical lures were also corrected using (*FA(CL) - FA(U))* where *FA(CL)* is the false alarm rate for critical lures. Finally, false alarms for related items were transformed using (*FA(R) - FA(U))* where *FA(R)* is the false alarm rate for non-presented related items.

Hit rates

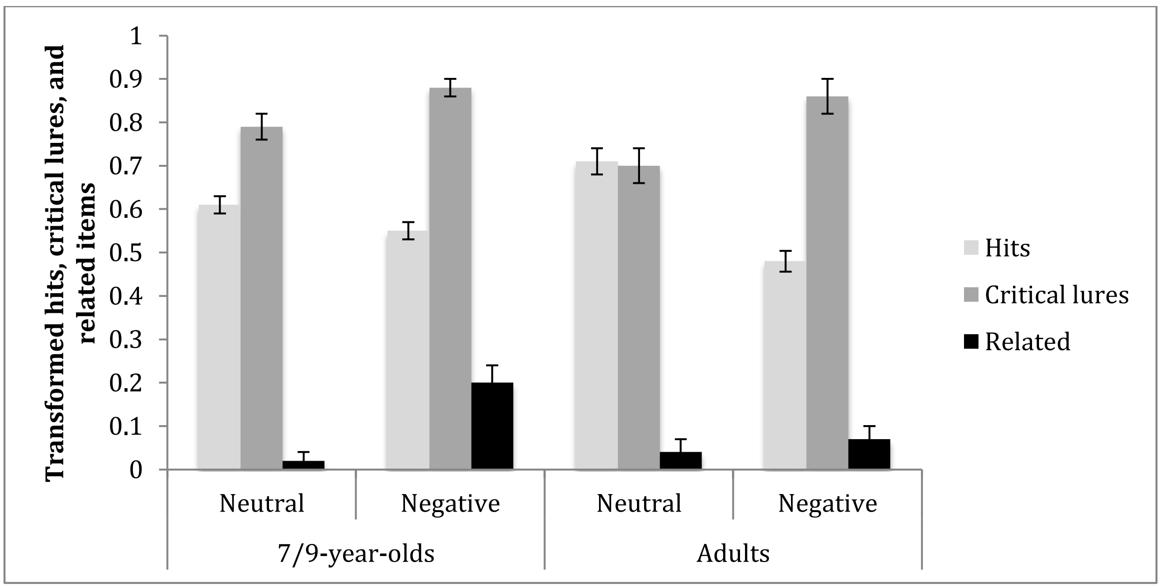
Our mixed-measures ANOVA showed a significant Age x Emotion interaction ($F(1, 70) = 9.96$, $p = .002$, $\eta^2_{partial} = .13$). Follow-up simple main effect analyses showed that only for the adults, neutral stories ($M = .71$, $SD = .25$) were better remembered than negative stories ($M = .48$, $SD = .21$; $F(1, 38) = 41.02$, $p < .001$, $\eta^2_{partial} = .52$). For the children, this difference was not significant ($F(1, 32) = 2.97$, $p = .09$, $\eta^2_{partial} = .09$).

False recognition

Interestingly, no age effect emerged for false recognition ($F(1,70) = 1.53$, $p = .22$, $\eta^2_{partial} = .02$). As expected, we found no evidence that children were more susceptible to suggestion-induced false memories than adults. That is, children ($M = .84$, $SD = .15$) and adults ($M = .78$, $SD = .24$) did not differ significantly in their false memory rates. We also conducted a Bayesian analysis and found a Bayes $\text{Factor}_{(10)}$ of 0.40 which indicates that our data are more likely to support the null hypothesis (= no age difference) than the alternative hypothesis (= age difference). We also found a statistically significant effect for emotion ($F(1, 70) = 9.61$, $p = .003$, $\eta^2_{partial} = .12$) with higher false memory rates for the negative ($M = .87$, $SD = .24$) relative to the neutral stimuli ($M = .74$, $SD = .28$). No significant interaction emerged ($F(1, 70) = 0.64$, $p = .43$, $\eta^2_{partial} = .01$; Figure 1).

Figure 1

Hits, False Recognition, and Non-presented Related Items as a Function of Age and Emotion (Means (Proportions) and Standard Errors (in Parentheses); Experiment 1).



False alarms for related non-presented items

Focusing our analyses on the non-presented related items, no interaction emerged ($F(1,70) = 3.38$, $p = .07$, $\eta^2_{partial} = .05$) and there was no significant age effect ($F(1, 70) = 1.60$, $p = .21$ $\eta^2_{partial} = .02$). However, again we obtained a significant main effect of emotion ($F(1, 70) = 7.99$, $p = .006$, $\eta^2_{partial} = .10$) with negative related items ($M = .13$, $SD = .29$) being more frequently recognized than neutral related items ($M = 0.03$, $SD = 0.20$).

This experiment demonstrates that development patterns in suggestion-based false memories can be modified when the materials used contain associatively related information. As expected, we found that negative stimuli were more likely to engender false memories than neutral stimuli. Importantly, we did not find evidence for an Age x Valence interaction showing that valence had an effect on false memory rates independent of age.

Using a combined DRM/misinformation paradigm, our most important finding was that children and adults did not differ in their propensity to accept misinformation. This is a hitherto unreported finding in the false memory literature that arose because we modified the misinformation paradigm in line with theoretical assumptions contained in models (i.e., AAT, FTT) of false memory that resulted in the reversal of developmental trends in suggestion-based false memories. That is, because false memories rely on participants being able to extract the meaning of experiences, when conditions are created where the meaning is made obvious, even young children (7/9-year-olds) evince false memory rates that rival those of adults. The combined DRM/misinformation approach likely resulted in an attenuation of the developmental trend that is commonly found in suggestion-induced false memories (false memories decrease with age). However, an equally plausible explanation is that the presentation of misinformation caused an attenuated developmental reversal (false memories increase with age). In our pilot experiment, we found that without misinformation, children had lower false memory rates than adults. Experiment 1 showed that including misinformation in which the critical lure was included led to no differences in suggestion-induced false memory propensity. One might argue that our attenuation effect is due to young children's susceptibility to accept misinformation in general. However, this is unlikely because then one would expect adults to be less prone to misinformation than children. This is not what we found. Our result is in line with our argument that misinformation about story contexts might lead to more obvious themes, ones that would increase children's but not adults' false memory rates.

Experiment 2: DRM and Memory Conformity Effects

The purpose of Experiment 2 was to examine whether an adaptation of the memory conformity paradigm could also lead to changes in the typical developmental trend for suggestion-induced false memories. Compared to developmental studies of suggestibility, there are only a few experiments on the development of memory conformity effects (Candel et al., 2007; McGuire et al., 2015). Furthermore, as mentioned earlier, these memory conformity experiments have produced mixed findings. One study (Candel et al., 2007) found evidence for developmental increases (for cued recall) and decreases (for free recall) in memory conformity effects while another study found developmental invariance in memory conformity effects (McGuire et al., 2015). There are several reasons why there are discrepancies across these studies, not the least of which was the use of an inappropriate age range to assess developmental differences in false memories (McGuire et al., 2015) or uncertainty as to whether the presented stimuli actually contained associatively-related details (Candel et al., 2007).

In Experiment 2, we included more age groups (7/8-year-olds, 11/12-year-olds, and adults) who were presented with neutral (e.g., kitchen) and negative (e.g., bicycle accident) pictures containing associatively-related details. These pictures were specifically constructed in line with how DRM wordlists are commonly developed (see below). Participants viewed these pictures in pairs and they believed they were viewing the same pictures. However, during this presentation, slightly different pictures were shown to the different individuals in the pairs. After viewing these different versions of the picture, participants had to recall what they could remember both collaboratively in their pairs and then individually. The basic prediction was that the presentation of associatively-related stimuli would activate related, non-presented concepts which would be reported during the two recall sessions. Based on previous developmental memory conformity experiments, no specific predictions could be made concerning age effects. However, based on AAT and FTT, one might hypothesize that the presentation of such associatively-related material would lead to more false memories in adults than in children thereby evincing a developmental reversal effect.

However, AAT provides an additional possibility which is that by presenting pictures with an obvious theme (e.g., kitchen), this should increase children's false memory rates (Howe et al., 2009; Otgaar et al., 2014). The reason is that adults' knowledge base is more developed and integrated than that of children's. The presentation of pictures containing a clear theme would not lead to more false memories for adults but for children, this should help them to identify the theme and make additional (correct and incorrect) associations. Indeed, studies have revealed that stimili with obvious themes frequently elevate children's false memory rates more than adults' false memory rates (Howe & Wilkinson, 2010; Otgaar et al., 2014). Based on this, our adapted memory conformity procedure should also lead to changes in typical developmental trends in false memory rates.

Method

Participants

We conducted an à-priori power analysis with a medium effect size *(f = 0.375, η^2_p = 0.13)* and high power (0.95) leading to a sample size of 87 (Faul et al., 2007). We tested 90 participants consisting of 30 7/8-year-olds (*M* = 7.63, *SD* = 0.49, range = 7-8; 13 boys), 30 11/12-year-olds (*M* = 11.50, *SD* = 0.51, range = 11-12; 16 boys), and 30 adults (*M* = 21.50, *SD* =

2.89, range = 18-31; 5 men). The children were recruited from Dutch primary schools, after parental consent and approval of their respective schools. Children received a small present for their involvement. The adults were all students from Maastricht University and were rewarded with course credit or a small financial compensation for their participation (7.50 euro). The current experiment was approved by the standing ethical committee of the Faculty of Psychology and Neuroscience, Maastricht University.

Materials

Pilot study. We conducted a pilot study to construct the necessary material for our experiment. Twenty-four undergraduate students (M_{Age} = 21.92, *SD* = 2.10; 11 men) were asked to complete a form in which they were presented with 3 neutral (kitchen, school, desk) and 3 negative (bicycle accident, prisoner, theft) descriptions of scenes. The instruction was to come up with as many details that were related to the scenes. They had to provide a minimum of five details for each scene and the task lasted approximately 12 minutes (2 minutes for each scene). The data were analyzed and we looked at details that were mentioned most often and earliest across participants. Participants came up with many different items (*N* = 284). Those items that were mentioned most often were generally also mentioned the earliest and these items were used for the construction of pictures.

Pictures. Based on the pilot data, we selected 4 descriptions (2 neutral: kitchen and desk; 2 negative: bicycle accident, prisoner) of which we devised pictures. Each picture contained 11 or 12 associatively related details based on the details that were in the pilot indicated as most associated to the scene (e.g., desk: *books, chair, laptop, note bloc, pencil, paper, telephone, marker, bottle of water, candy, case*). For each of the pictures, two slightly different versions were constructed that diverged on critical items: Versions A and B. Each picture version included a critical item that was associatively related to the scene but not present in the other picture version. For all four pictures, this led to a total of 8 critical items. The pictures were presented for 20 seconds each with 4-second interstimulus intervals. Each member of a pair viewed a different picture version and thus saw the opposite picture versions of those that the other pair member was presented with. Pairs of participants were positioned at opposite sides of a table and received the pictures at the same time. Picture order and version was randomized per pair and each individual member of a pair viewed their pictures in the same order but received the opposite version.

Design and Procedure

Experiment 2 used a 3 (Age: 7/8-year-olds, 11/12-year-olds, and adults) x 2 (Emotion: neutral vs. negative) mixed design with the latter factor being a within-subject factor. Children were tested in quiet rooms at their elementary schools. The students were tested by two research administrators in quiet testing rooms at the Faculty of Psychology and Neuroscience, Maastricht University. Participants were always tested in pairs within their own age group. They were informed that they were involved in a memory experiment using pictures and different age groups.

Pictures were presented to pairs of participants. Participants unknowingly received pictures that were slightly different than those presented to the other pair member. After this, participants received a 5-min lasting distractor task (i.e., playing Tetris). Next, they were instructed to discuss and recall all of the details from the pictures that they could remember. Before the discussion, participants were instructed to reply to each other per mentioned detail, by indicating whether they did or did not remember that detail, or whether they were unsure. After the collaborative discussion, participants played Tetris once more for five minutes. Then, in separate rooms each participant was instructed to individually recall what they remembered from the pictures as if they were a witness asked by the police to report what they had seen. Participants had to mention only those details that they themselves remembered from the pictures. Finally, participants were debriefed about the purpose of the study.

Scoring

For the memory conformity paradigm, hits in recall were scored by the amount of correctly reported associatively-related details as a proportion of the total number of associatively-related details presented. Furthermore, we looked at the critical hits (reports of seen critical items). False critical recall (reports of critical items from the other picture versions) was also separately recorded and assigned one point per item. Finally, intrusions (false recall of items not present in either version of the pictures) were recorded as well.

Results and Discussion

First, we present the proportion of hits and false memory rates. However, because intrusions were statistically higher in younger children than in older children and adults, we have also conducted analyses on corrected scores (see Exploratory Analyses).

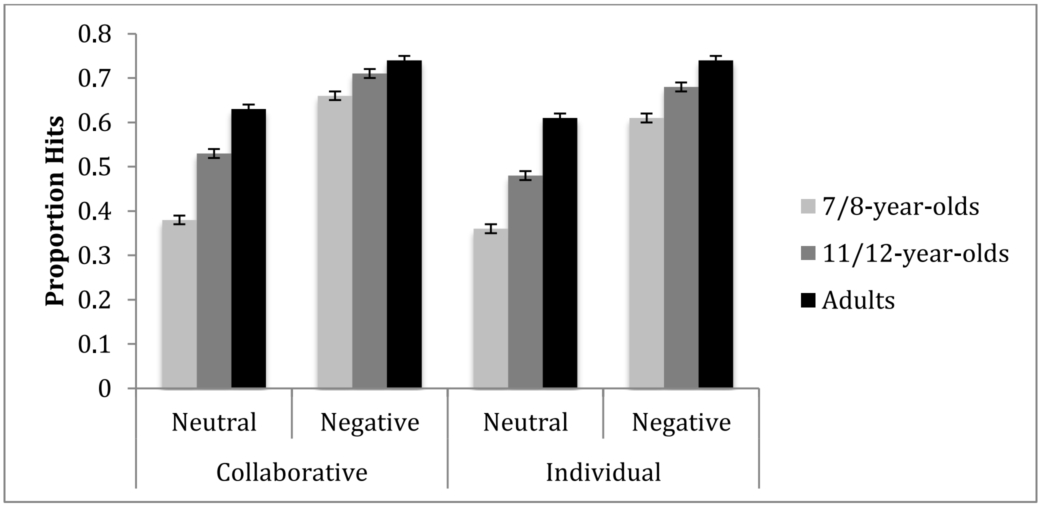
Memory Conformity: True Memory

We first examined the hit rates during the collaborative recall phase by using a 3 (Age: 7/8-year-olds, 11/12-year-olds, and adults) x 2 (Emotion: Neutral vs. negative) repeated measures ANOVA. Our analysis found a statistically significant Age x Emotion interaction (F(2, 87) = 15.94, $p < .001$, $\eta^2_p = .27$). Simple main effects showed that for all age groups, an emotion effect was observed (F(1, 87) = 203.05, $p < .001$, $\eta^2_p = .70$) with higher hit rates for the negative (M = 0.70, SD = 0.08) than neutral pictures (M = 0.51, SD = 0.14). Second, for neutral hit rates using post-hoc Bonferroni tests, we found that adults (*M* = .63, *SD* = 0.08) had statistically higher hit rates than 11/12-year-olds (*M* = 0.53, *SD* = 0.10) who in turn had statistically higher hit rates than 7/8-year-olds (*M* = 0.38, *SD* = 0.11; $F(2, 87) = 51.84$, $p < .001$, $\eta^2_p = .54$). Although we also found a statistically significant age effect when only focusing on the negative hit rates ($F(2, 87) = 6.78$, $p = .002$, $\eta^2_p = .14$), adults (*M* = 0.74, *SD* = 0.08) and 11/12-year-olds (*M* = 0.71, *SD* = 0.08; $p = 0.42$) did not differ statistically in their hit rates. Only younger children (*M* = 0.66, *SD* = 0.07) had lower hit rates than older children ($p = .02$) and adults ($p < .001$; Figure 2).

When we concentrated on hit rates during individual recall, we again found a statistically significant Age x Emotion interaction ($F(2, 86) = 8.29$, $p = .001$, $\eta^2_p = .16$). When we performed simple effects tests, we found for the neutral hit rates ($F(2, 86) = 41.89$, $p < .001$, $\eta^2_p = .49$), that adults had statistically higher scores (*M* = 0.61, *SD* = 0.09) than 11/12-year-olds (*M* = 0.48, *SD* = 0.12) who in turn had higher scores than the youngest age group (*M* = 0.36, *SD* = 0.09, all *p*s < .001). Although similar effects were obtained for the negative hit rates ($F(2, 86) = 13.71$, $p < .001$, $\eta^2_p = .24$), the effects were much smaller than for the neutral hit rates ($\eta^2_p = .49$).

Figure 2

Hits as a Function of Age and Emotion (Means and Standard Errors (in parentheses; Experiment 2).



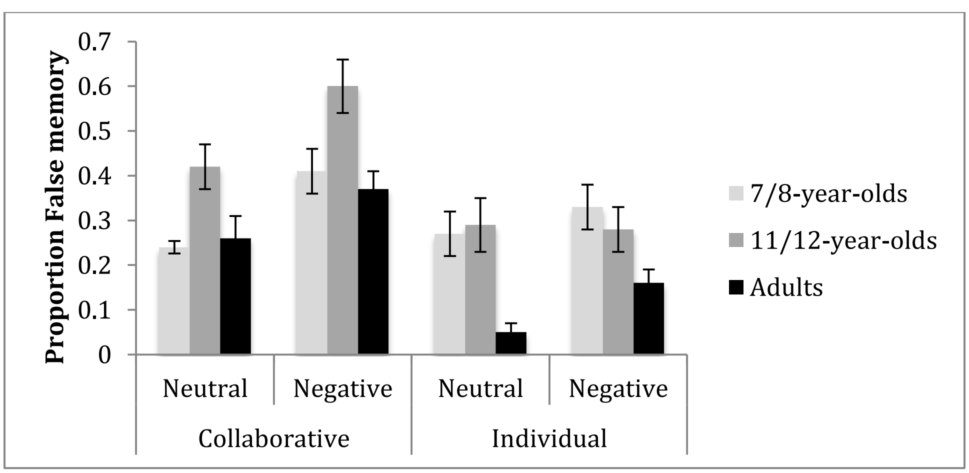
Memory Conformity: False Memory

We conducted a 3 (Age: 7/8-year-olds, 11/12-year-olds, and adults) x 2 (Emotion: Neutral vs. negative) repeated measures ANOVA on the false memory rates during the collaborative recall phase. Interestingly, as in Experiment 1, false memory rates did not differ statistically between the different age groups ($F(2, 86) = 2.68$, $p = .07$, $\eta^2_p = .06$; 7/8-year-olds: $M = 0.33$; 11/12-year-olds: $M = 0.51$; adults: $M = 0.33$). Indeed, we obtained a Bayes Factor$_{(10)}$ of 0.64 which implies that our data are more in favor of the null (= no age difference) than alternative hypothesis (= age difference). We found that negative false memory rates ($M = 0.46$, $SD = 0.47$) were statistically higher than neutral false memory rates ($M = 0.31$, $SD = 0.45$; $F(1, 86) = 5.57$, $p = .02$, $\eta^2_p = .06$). The interaction was not significant ($F(2, 86) = 0.26$, $p = .77$, $\eta^2_p = .006$).

When we focused our analysis on the false memory rates during the individual recall phase, a somewhat similar age pattern was observed as for the collaborative false memory rates. That is, although an age effect was detected ($F(2, 81) = 3.54$, $p = .03$, $\eta^2_p = .08$), post-hoc Bonferroni analyses did not find any statistical differences between the age groups (*p*s > .07; 7/8-year-olds: $M = 0.30$; 11/12-year-olds: $M = 0.28$; adults: $M = 0.10$). Our Bayes Factor$_{(10)}$ was also very small (=1.26) which again suggests that our data are more in line with the null than alternative hypothesis. To test whether any unrelated intrusions resulting from a response bias might be more present in children than in adults, we conducted a univariate ANOVA on the intrusion rates during the individual recall phase. A statistically significant age effect was observed ($F(2, 86) = 14.70$, $p < .001$, $\eta^2_p = .26$) with younger children ($M = 3.52$, $SD = 3.01$) having statistically higher intrusion rates than older children ($M = 1.57$, $SD = 1.52$; $p = .001$) and adults ($M = 0.77$, $SD = 0.90$, $p < .001$; Figure 3).

Figure 3

False Memory as a Function of Age and Emotion (Means and Standard Errors (in parentheses; Experiment 2).



Exploratory Analyses

Because of the possibility of a response bias, we also explored age effects in memory conformity for corrected false memory scores. Specifically, we transformed the false memory data (collaborative and individual) using the following formula: z_{score}-False Memory minus z_{score}-Intrusion. Intrusions provided by participants could vary on many dimensions and hence, we examined age effects on the corrected and combined false memory scores of neutral and negative stimuli.

For the corrected collaborative false memory scores, a univariate ANOVA with Age as between-subjects factor was performed. Our analysis showed a developmental reversal effect ($F(1, 87) = 15.94$, $p < .001$, $\eta^2_{partial} = .27$) with 7/8-year-olds ($M = -3.21$, $SD = 3.06$) having statistically lower corrected false memory scores than 11/12-year-olds ($M = -1.19$, $SD = 2.21$; $p = .002$) and adults ($M = .01$, $SD = 0.84$; $p < .001$).

For the corrected individual false recall scores, we conducted a univariate ANOVA with Age as between-subjects factor. Our analysis evinced a developmental reversal effect ($F(1, 70) = 9.61$, $p = .003$, $\eta^2_{partial} = .12$). That is, Bonferroni post-hoc comparisons showed that adults ($M =$ --0.87, $SD = 1.13$) had higher corrected false memory scores than younger children ($M = -4.13$, $SD = 3.71$; $p < .001$). Corrected false memory scores were also statistically higher in older ($M = -1.73$, $SD = 1.99$) than younger children ($p = .001$). Adults' and older children's corrected false memory scores did not statistically differ ($p = .57$).[2]

In Experiment 2, we modified the memory conformity paradigm by presenting children and adults with neutral and negative pictures with an obvious theme (e.g., desk) containing associatively-related details. The reasoning behind this was that, just as in the DRM paradigm, the presentation of associatively-related stimuli would change the typical developmental trend in suggestion-induced false memories (age-related decrease). That is, when children and adults receive such associatively-related stimuli and are presented with suggestion, children will *not* be more susceptible to suggestion than adults. Instead, children can benefit from such obvious themes thereby being equally vulnerable to false memory development as adults (Otgaar et al., 2014). Moreover, such an adapted procedure might even result in developmental reversals with adults being more susceptible to suggestion-induced false memories than children (Brainerd et al., 2008; Otgaar et al., 2016).

As anticipated, in Experiment 2 we found evidence that when participants were presented with associatively-related stimuli consisting of obvious themes, children were equally susceptible to memory conformity effects as adults. This effect was most evident for the collaborative recall phase. This is in line with previous research showing that developmental trends can become attenuated when stimuli with obvious themes are presented to subjects (e.g., Howe & Wilkinson, 2011; Otgaar et al., 2014). More interestingly, when we explored the transformed false memory scores by correcting for a possible response bias, our analyses showed a reversal effect where adults' false memory scores were least affected by response bias.

General Discussion

The current experiments were designed to assess whether the usual developmental trend in suggestion-based false memories could be changed. Specifically, research has revealed that when presented with suggestive pressure, children are more prone to false memories than adults (Bruck & Ceci, 1999). Such patterns have been found in many different false memory procedures including the misinformation paradigm (Otgaar et al., 2010). In the current experiments, we adapted two frequently used false memory procedures – misinformation and memory conformity – in such way that we could test whether this usual developmental trend in false memories can be changed. What we have demonstrated is that these typical developmental trends in suggestion-induced false memories are indeed malleable. That is, in both experiments, we found that children were equally susceptible to false memories as adults and when bias-corrected scores are used, children were less vulnerable to memory illusions produced through conformity effects than were adults.

Examining the malleability of developmental trends in suggestion-induced false memories is relevant because another type of false memory, spontaneous false memories, exhibits the opposite developmental trajectory. That is, numerous studies have demonstrated a developmental reversal in which children are less likely to produce false memories than adults (see for an overview, Brainerd et al., 2008). This effect has been anticipated by theories such as FTT (Brainerd et al., 2008) and AAT (Howe et al., 2009; Otgaar et al., 2014). Both of these theories have fleshed out the conditions needed to reveal a developmental reversal effect, conditions that include developmental improvements in meaning extraction and associative activation. Studies showing this reversal effect have commonly used meaning related materials, such as those found in the DRM paradigm, where children, because of their difficulty with extracting meaning and lower levels of associative activation, are less likely to form false memories than adults.

We adapted the misinformation and memory conformity procedure in line with principles behind the DRM paradigm. By doing so, we made sure that false memories induced by misinformation were predominantly the result of relying on the associative structure and meaning of an experience and not because of external factors such as social pressure. Specifically, in our experiments, we made sure participants were presented with associatively-related stimuli (i.e., stories (Experiment 1); pictures (Experiment 2)) and were then presented with suggestions that preserved the underlying theme or meaning of the stimuli. Our prediction, derived from AAT and FTT, was that this new procedure would lead to developmental reversals in suggestibility effects. Furthermore, AAT postulates that the presentation of stimuli with obvious themes would also lead to false memory attenuation effects (no statistical difference in false memories between children and adults).

The current experiments extended these principles and demonstrated that when children and adults are given associatively-related (DRM) materials in the form of stories and are then presented with misinformation containing the non-presented critical lure of the stories, misinformation effects were equally likely to occur in children and adults (Experiment 1). Obviously, this finding runs counter to the usual finding that misinformation effects are more prevalent in children than in adults (e.g., Otgaar et al., 2010; Sutherland & Hayne, 2001). It is important to emphasize that when we conducted the pilot study for Experiment 1, we showed that these same stories *without* any misinformation exhibited the usual developmental reversal effect (age-related increases in false memories). When we added misinformation to this procedure we were able to eliminate these age differences, showing that misinformation effects do not necessarily occur more often in children than in adults.

Experiment 2 used an adapted memory conformity procedure to foster suggestion-induced false memories. Younger and older children and adults were presented with pictures of scenes (e.g., desk) containing associatively-related details. Participants believed they were viewing the same pictures whereas in fact the pictures diverged on certain critical items. Participants had to report what they could remember of these pictures during both a collaborative and an individual recall phase. Again, we found that memory conformity effects were similar in all age groups. Moreover, when we explored bias-corrected false memory scores, we found that adults had higher corrected scores than children suggesting the presence of a developmental reversal. One potential explanation for this effect was that adults' false memory scores were less affected by response bias than children's. Of course, we mentioned earlier that previous developmental memory conformity work has revealed inconsistent results (Candel et al., 2007; McGuire et al., 2015) with one study finding an age-related decrease for cued recall (Candel et al., 2007) and another study finding no developmental differences (McGuire et al., 2015). However, in McGuire and colleagues' study, they used a restricted age range and in Candel et al.'s research, no control was present concerning whether the stimuli were associatively-related to each other. In our second study, we attempted to solve these issues, but of course future research should be conducted to test whether our memory conformity results can be replicated.

A subsidiary aim of the present experiments was to examine developmental reversal effects in neutral and negative false memories. Previous research has found that reversal effects emerge independent of the emotional nature of stimuli (Brainerd, Holliday, Reyna, Yang, & Toglia, 2010; Howe, Candel, Otgaar, & Malone, 2010). However, most of this research has focused exclusively on emotion and developmental reversal effects in spontaneous false memories. There is only limited knowledge on whether emotionally-charged stimuli differentially affects developmental reversal effects in suggestion-induced false memories (but see Otgaar et al., 2016). Our experiments showed that developmental patterns in false memory occurred irrespective of the emotional nature of the stimuli. Furthermore, we found that negative false memories were more easily elicited than neutral false memories, a finding that aligns well with observations showing that it is easier to extract meaning from negative experiences (Rivers, Reyna, & Mills, 2008) or that associative activation spreads faster and more automatically through emotionally-negative memories (Howe et al., 2010).

Our attenuation and reversal effects in suggestion-induced false memories can be explained by AAT and FTT. For our effects in the memory conformity paradigm, when children and adults were presented with associatively-related stimuli and received suggestion preserving the theme of the event, adults were more likely to extract the underlying meaning or make relations with other (related) concepts than children. This resulted in higher false memory levels in adults than in children. Our attenuation effects may be due to the effect of themes on false memory development. That is, the themes of the stimuli that we used (stories and pictures) can easily be identified. When, for example, a picture of a bicycle accident is presented, participants can easily see what the picture is about. However, children's knowledge base is less well-developed than adults and hence, children benefit more from such themes than adults who already have sufficient knowledge concerning those themes (Carneiro, Fernandez, & Dias, 2009). The consequence of making themes more obvious is that false memory rates will increase in children whose knowledge base and meaning extraction skills are worse than those for adults, thereby attenuating the usual development trend (increases) in false memory production.

It might be argued that our experiments are somewhat limited because we used rather simple stimuli to investigate developmental reversals in suggestion-induced false memories. However, our experiments were purely focused on using theoretical principles (e.g., meaning extraction, associative activation) in order to alter developmental trajectories in false memories. Therefore, although we may have used rather simple stimuli, these stimuli were ideal for our main goal as we had considerable control over the construction of these stimuli. Furthermore, we have recently used more ecologically valid and forensically-oriented stimuli (negative videos) and have also obtained developmental reversals in false memory rates (Otgaar et al., 2016).

The core message of the current experiments is that age trends in false memories are not developmentally invariant and that they can be altered quite easily. This is relevant because it confirms the importance of using theoretical tenets when predicting forensically-relevant developmental patterns of false memory and evaluating the reliability of eyewitness memory. Legal professionals and memory researchers have long thought that because of their increased proneness to false memories, children make unreliable witnesses (see also Wolffram, 2015). However, evidence is accumulating that age, by itself, cannot be used to predict false memory propensity (Brainerd, Reyna, & Zember, 2011; Otgaar et al., 2016). Instead, our research suggests that other factors should be taken into account when, for example, legal professionals (e.g., police) want to assess a witness' vulnerability to false memories. One likely candidate is to assess the witness' knowledge base , something that could be measured using the DRM paradigm. Interestingly, in legal cases, proneness to suggestive questions is often estimated by providing the Gudjonsson Suggestibility Scale (Gudjonsson, 1984). Along those lines, it would be relevant to examine whether the DRM paradigm might lead to a valid index of someone's knowledge base and susceptibility to false memories. Indeed, there is some research suggesting that DRM false memories are positively related to suggestion-based false memories (Zhu, Chen, Loftus, Lin, & Dong; but see also Ost, Blank, Davies, Jones, Lambert, & Salmon, 2013; Otgaar & Candel, 2011).

To conclude, the present experiments show that increased susceptibility to suggestion and false memories is not a unique feature of children. On the contrary, we have shown that both children and adults can be highly vulnerable for the formation of suggestion-induced false memories. Such findings are significant as they provide a more balanced picture of the reliability of eyewitness statements and show that children are not by definition inferior witnesses.

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Footnote

[1]We refer to spontaneously-induced false memories when false memories are *not* induced through external (suggestive) pressure but occur because of reliance on associative activation or gist extraction

[2]Participants also received 5 DRM lists and a recall task. Our analysis evinced a developmental reversal effect ($F(1, 70) = 9.61$, $p = .003$, $\eta^2_{partial} = .12$).