The Production of Spontaneous False Memories in Childhood

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This paper has been supported by a grant from the Edmund Hustinx Foundation and by a grant from the Netherlands Organization for Scientific Research (NWO 415-12-003) to HO and by a grant from the Economic and Social Research Council to MLH (RES-062-23-33270.

IN PRESS: *Journal of Experimental Child Psychology*

Abstract

We found evidence that the usual developmental trends in children’s spontaneous false memories were eliminated using novel stimuli containing obvious themes. That is, children created more false memories than adults when scenes had to be remembered. In Experiment 1, 7/8-year-olds had higher false memory rates than adults when using visual scenes. Experiment 2 showed that gist cuing could not account for this effect. In Experiment 3, children and adults received visual scenes and story contexts in which these scenes were embedded. For both types of stimuli, we found that children had the highest false memory rates. Our results indicate that the underlying theme of these scenes is easily identified resulting in our developmental false memory trend.

Keywords: False memory, Development, Memory

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Given the central importance of memory to our everyday lives, it is not surprising that there has been considerable debate among scientists and philosophers concerning the precise mechanisms by which memory operates and how it often results into erroneous or false memories. In the false memory literature, one can broadly distinguish between two types of false memories. Numerous studies have focused on the formation of *suggestion-induced* false memories. These memory aberrations are the consequence of suggestive manipulations (e.g., Otgaar, Sauerland, & Petrila, 2013).

The current article focuses squarely on the issue of the development of *spontaneous* false memories. These are the types of false memories that arise *without* any external suggestive pressure and are the sole result of endogenous mechanisms such as spreading activation (Brainerd et al., 2008). We present a novel set of three experiments examining specific conditions that modify (attenuate or reverse) the usual developmental trends in spontaneous false memories. To foreshadow our findings, we will show that developmental patterns in spontaneous false memories can be manipulated depending on whether certain theoretical conditions are met.

Spontaneous False Memories: The Classic Paradigm

Spontaneous false memories are often induced using the Deese/Roediger-McDermott (DRM) paradigm (Deese, 1959; Roediger & McDermott, 1995). In this paradigm, word lists consisting of related words (e.g., weep, sorrow, wet) are presented to participants. These words are associatively related to a nonpresented critical theme word called the critical lure (i.e., cry). Recall and recognition tests show that participants often falsely recollect the critical lure at rates comparable to that of true memory rates (Roediger & McDermott, 1995). The interest in the DRM paradigm stems partially from the fact that the DRM illusion is a robust memory phenomenon and that, at least for adults, they are difficult to inhibit because of its automatic nature (Howe, 2005; Howe, Wimmer, Gagnon, & Plumpton, 2009).

To be more specific, many memory researchers make use of the DRM paradigm because it provides a robust tool to assess the cognitive mechanisms behind false memories (Brainerd et al., 2008). Why the DRM paradigm also attracts much scientific attention is because studies show that the DRM illusion is related to false autobiographical memories which implies that this task could be used to make inferences about autobiographical memory (Gallo, 2010; but see also Otgaar & Candel, 2011). Furthermore, developmental studies using the DRM paradigm show an age-related increase in the production of false memories with children being less susceptible to DRM false memories than adults (Brainerd et al., 2008; Brainerd & Reyna, 2012; Howe et al., 2009). This developmental reversal in spontaneous false memories has been obtained in a growing number of studies on children's false memory development (e.g., Brainerd & Reyna, 2007; Howe, 2007; Otgaar & Smeets, 2010).

Two main theoretical accounts offer an explanation for the formation and developmental of spontaneous false memories. Fuzzy-trace Theory (FTT; Brainerd et al., 2008) was the first framework to predict the increase in spontaneous false memories with age. For FTT, experiences are stored in parallel in two opponent traces, a verbatim trace and a gist trace. Verbatim traces encode the surface and item-specific details of an experience whereas gist traces capture the underlying meaning of an experience. False memories occur because when verbatim traces are not available, people rely on the gist of an experience. Items retrieved that are consistent with the gist of an experience (e.g., word list) can be falsely remembered given the absence of contradictory (e.g., verbatim) information. In addition, FTT suggests that because children are less likely to extract the gist of an experience than adults, they should be less susceptible to false memories. Indeed, memory studies have reliably shown that children are less able to link meaning to information and less likely to extract relationship between different parts of information within an experience than adults (see Bjorklund, 1987, 2005; Esposito, 1975).

Associative-activation Theory (AAT; Howe et al., 2009) provides an alternative approach to the development of different types of false memories, one that also anticipates age differences in knowledge base and automatic processing. AAT, which is partially based on Activation-monitoring Theory (AMT; Roediger, Watson, McDermott, & Gallo, 2001), postulates that the most important factor underlying false memory production is the nature of the person's knowledge base and the type of automatic activation of information that it affords. AAT (like AMT) derives from the core notion of spreading activation in memory. Here, processing of one word or concept leads to a spread of activation to corresponding and related nodes and concepts in our knowledge base (mental lexicon) (Anderson, 1983; Collins & Loftus, 1975; Landauer & Dumais, 1997). That is, one concept activates other related concepts in memory where some of these activations involve concepts that were not presented. These nonpresented concepts have been erroneously activated because of their close link (association) with presented concepts in the knowledge base. These associative relations can vary immensely ranging from perceptual information (e.g., phonological relations) to conceptual or semantic links (e.g., category, synonym, antonym) (see also Wu & Barsalou, 2009).

AAT suggests that false memories arise due to changes in the contents, structure, and speed of access of information in one's knowledge base (e.g., growth of associative relations, reorganization of knowledge, automaticity of access). That is, children's and adults' false memories vary in the degree of automaticity of associative activation which in turn is driven by developments in children's knowledge base (Howe, 2005; Howe & Wilkinson, 2011; Otgaar, Candel, Scoboria, & Merckelbach, 2010; Otgaar, Smeets, & Peters, 2012). False memory rates increase with age because children gain knowledge and experience through learning, practice, and exposure to new information which results in a better integrated memory network of conceptual representations and associative relations among concepts (Bjorklund, 1987, 2005).

Despite important differences between them, both AAT and FTT can account for many of the extant findings concerning developmental trends in spontaneous false memories using the DRM paradigm. Recently, researchers have resorted to the use of other paradigms to evoke spontaneous false memories. As Howe and Wilkinson (2011, p. 80) stated: "[t]he questions that arise from a consideration of both associative activation theory and fuzzy trace theory is whether there is any evidence that children's spontaneous false memories occur using materials other than word lists and whether the use (implicit or explicit) of contexts or themes alters the typically observed developmental increase in true and false memories." The overarching aim of the present studies was to examine developmental trends in spontaneous false memories with material other than the oft-used DRM word lists.

Spontaneous False Memories: Nontraditional Paradigms

Earlier research (e.g., Paris & Carter, 1973) showed that 7- and 10-year old children falsely remembered nonpresented, yet semantically related sentences, among presented sentences. Also, Brown, Smiley, Day, Townsend, and Lawton (1977) showed that when 8-year-old children received a story, they falsely identified sentences that were associated with sentences in the story.

More recent false memory studies have focused on the inclusion of DRM lists in story contexts in an attempt to investigate the development of false memories (Dewhurst, Pursglove, & Lewis, 2007; Howe & Wilkinson, 2011). The rationale of these studies was to examine false memories under conditions in which DRM word lists are transformed into semantically dense, coherent story contexts. This leads to DRM word lists possessing an obvious context that makes the semantic structure of these lists even clearer and makes the theme more obvious, something that should impact false memory rates especially for younger children.

In one of the first studies, Dewhurst and colleagues (2007; also see Swanell & Dewhurst, in press) tested the influence of stories on the formation of false memories. Five-, 8-, and 11-year-olds were presented with the original DRM paradigm and a modified version in which the DRM stimuli were embedded in stories. They found that the 5-year-olds had lower false memory rates than the older children when they were presented with the standard DRM lists. However, when story contexts were used, developmental patterns in false memories were significantly attenuated and even slightly reversed. Specifically, story contexts significantly enhanced 5-year-olds' vulnerability to false memories such that they were even higher than false memory rates of the older children. The reason for this finding was that the stories provided an explicit thematic context, one that particularly benefited younger children's ability to process the meanings of the words. As older children are better at extracting the meaning of associative information than younger children, the additional context in which these stories were offered did not influence older children's false memory production as much as that of younger children's.

As Howe and Wilkinson (2011) argued, theme nodes (or links between concepts) are also part of associative networks and these theme nodes become directly activated during story presentations (see Figure 1). Howe and Wilkinson (2011) also used story contexts to foster false memory creation and found that depending on which one of two mutually exclusive themes was targeted by the story context, different theme-consistent false memories were generated by 7- and 11-year-olds. In addition, they found that although the typical developmental trend was present when using standard DRM lists, developmental trends in false memories were greatly reduced when story contexts were used as stimuli.

Although these studies used story contexts, conclusions are still somewhat restricted inasmuch as they relied on verbal stimuli. Only a handful of studies have examined visual stimuli. For example, Koutstaal and Schacter (1997) gave younger and older participants detailed colored pictures of objects (e.g., chair). They were then presented with a subset of the studied pictures, together with pictures that were associated with the objects. Interestingly, they found that false recognition rates were higher in older than younger adults suggesting that older adults used the meaning of the presented pictures more often than the younger adults.

Howe (2008) also used colour photographs of objects from DRM lists either embedded in a homogenous (each item was photographed against the same colored background) or heterogeneous (each item was photographed against a different background) background. When participants (5-, 7-, and 11-year-olds) were shown these colour photographs in homogeneous backgrounds, the standard developmental trend in spontaneous false memories (older children produced more false memories than children) was obtained. However, when heterogeneous backgrounds were used, age differences in false memory rates disappeared. Thus, when items were made more distinctive using heterogeneous backgrounds, developmental trends in spontaneous false memories were attenuated or even eliminated.

Recently, Moritz, Woodward, and Rodriguez-Raecke (2006) constructed a false memory paradigm containing visual scenes for examining memory deficits in schizophrenic patients. They developed drawings of scenes (e.g., a beach) in which certain related elements were left out (e.g., a beach ball). They found that when these visual scenes were presented, both schizophrenia patients and controls falsely remembered nonpresented, but related elements, but these groups did not differ in terms of false memory rates. This work nicely parallels research by Miller and Gazzinaga (1998) who also used visual scenes to induce false memories. In these scenes, related elements were also removed and Miller and Gazzinaga found that this visual paradigm elicited similar rates of false memories as the DRM paradigm.

One could argue that these visual scenes are related to studies on the impact of schemas and scripts on memory, ones that show that although schemas (knowledge structures) can have a beneficial effect on memory, they can also result in memory distortions (e.g., Brewer & Treyens, 1981; Lampinen, Faries, Neuschatz, & Toglia, 2000). For example, Brewin and Treyens (1981) had participants enter an office after which they had to report everything they could recollect about the office. While participants correctly remembered objects that were also linked to an office schema (e.g., desk), they also incorrectly remembered nonpresented objects that were related to an office (e.g., shelves). Also, Erskine, Markham, and Howie (2001) showed younger and older children slides depicting a visit to McDonalds. They found that younger children made more script-related errors than older children. So, like the findings from the research using visual scenes (Moritz et al., 2006), it is likely that "real" scenes also rely on certain schemas and scripts that may influence true and false memory production.

The novel aspect of visual scenes is that, compared to standard DRM word lists, DRM pictures, and schema-related research, they are more comparable to the visual material that we encounter in our daily life. Indeed, many events (e.g., going to a cinema) that we experience in our life contain elements (e.g., eating popcorn, buying a ticket) that are (associatively) related to each other (Brainerd et al., 2011; Gallo, 2010). So, although research shows that the standard DRM paradigm is a valuable tool to study the mechanisms behind developmental trends of false memories, it is likely that this new visual false memory paradigm may be a better way to examine developmental trends in "real-life" false memories. An additional advantage of using scenes is that they provide an obvious context in which a certain theme can be activated, perhaps even more easily than that observed with story contexts.

The Present Research

In the present experiments, we took up this challenge and examined the formation of scene-based visual false memories in children (7/8-year-olds) and adults. This child age group has often been used in false memory research to study developmental trends in false memories (Brainerd et al., 2008). In our experiments, participants viewed different scenes and were then given a memory test in which they were asked if they recognized elements that were presented as well as those that had not been presented. Our principal goal was to examine whether standard developmental trends in spontaneous false memories would be affected by visual contexts in a similar or different manner as the effects found with story contexts. Most theories would predict that to the extent visual scenes make the gist or theme more evident, we should find that the standard developmental trend should be attenuated or even reversed. That is, adults may no longer exhibit higher levels of false memories than children.

Experiment 1

Method

Participants

A total of 40 participants (20 7/8-year-olds: mean age = 7.15 years, *SD* = 0.49, 10 boys; 20 adults: mean age = 22.05, *SD* = 3.59, 10 men) were involved in this study. Children were recruited from elementary schools in the Netherlands. Adult participants were undergraduates from the Faculty of Psychology and Neuroscience, Maastricht University. All children had parental consent and also consented themselves for participation. Children received a small present for their involvement. Adults were given course credits for their participation. The study was approved by the standing ethical committee of the Faculty of Psychology and Neuroscience, Maastricht University.

Materials

Visual scenes. A false memory paradigm containing visual scenes was used in the present study. The effectiveness of this false memory paradigm has been substantiated in previous research (Moritz et al., 2006; Peters et al., 2012). We used three black-and-white visual scenes of a classroom, funeral, and beach (see Moritz et al., 2006). Scenes were selected on several criteria: they should be broadly familiar from personal experience or other sources (e.g., books, movies), they should be easy to identify, and incorporate a high level of details. The scenes were also equated in terms of perceptual complexity. That is, the original artist of the pictures had to draw an equal amount of typical items for each of the scenes that later were counted as studied items. Furthermore, for each of the scenes the same number of prototypical items was removed, which later served as critical lures. Thus, each visual scene consisted of 12 prototypical items (i.e. presented items; e.g., sandcastle in the beach scene) and converged on 12 nonpresented items. Eight of these items were nonpresented, related critical lures (e.g., beach ball), 4 of them were nonpresented, unrelated items (e.g., car). The recognition task contained 36 previously presented items (total studied items; 12 studied items of each scene) and 36 nonpresented items (4 nonpresented, unrelated items for each scene and 8 unpresented related critical lures for each scene).

Design and Procedure

The present study employed a between-subjects design with Age (7/8-year-olds vs. adults) as independent variable and proportion hit rates (total hits), false recognition (critical lures), and not related items as dependent variable. All participants were informed that they took part in a memory study. Both children and adults were tested individually in separate and silent rooms respectively at their elementary school or university. Participants received the three visual scenes in a randomized order. We used Powerpoint to present participants with the visual scenes. Each visual scene was presented for 40 seconds with an interval of 3 seconds between the scenes. Each participant was instructed to closely attend to each of the scenes because they would be asked several questions about them. Before the recognition task, each participant received a 1 min. distractor task (Tetris). During the recognition task, items of one of the visual scenes were randomly presented along with a corresponding contextual cue (i.e., classroom, funeral, beach). This was done to make clear that each item referred to a specific picture. Participants were asked if they witnessed a particular item on one of the visual scenes. To facilitate the decision process, the corresponding contextual cues were presented along the items.

Results and Discussion

Hit rates and false recognition

We used independent samples t-tests to examine developmental trends in the visual false memory paradigm. For hit rates, there was no effect for age, (38) = 0.87, p = .39, indicating that children, *M* = 0.73, *SD* = 0.16, and adults, *M* = 0.69, *SD* = 0.09, did not differ significantly (see Table 1). For false recognition, we found a significant effect for age, $t(38) = 3.37$, $p = .002$, generalized eta squared ($?^2_g$) = .23 with 7/8-year-olds, *M* = 0.51, *SD* = 0.21, having higher false memory rates than adults, *M* = 0.31, *SD* = 0.15. When we looked at the acceptance of unrelated items, we did not find a significant effect, $t(38) = 0.94$, $p = .35$ (A similar age effect was detected when we examined whether each scene separately showed the same developmental trend as the collapsed data reported in the Results sections; $p < .05$).

Because of potential effects of a “yea-saying” bias, we transformed our scores using the two-high-threshold correction (Howe & Wilkinson, 2011; Snodgrass & Corwin, 1988). For hit rates, we calculated *H –FA(U)* where *H* designates the proportion hit rates and *FA(U)* refers to the proportion false alarms to unrelated items. For false recognition, we used *FA(CL) - FA(U)* where *FA(CL)* relates to the proportion false alarms of critical items. Using Analysis of Variance (ANOVA) and like the uncorrected scores, we found no main effect of Age, $p > .05$. However, we did again find that children, *M* = 0.36, *SD* = 0.21, had higher false memory rates than adults, *M* = 0.20, *SD* = 0.17; $F(1,38) = 6.92$, $p = .01$, $?^2_g = .15$.

Taken together, the important finding was that when looking at the raw and transformed recognition data, children had higher false memory rates than adults when exposed to visual stimuli consisting of related elements. This unique finding was obtained despite not obtaining any significant age effects for true recognition or recognition of unrelated items. What this suggests is that both true memories and unrelated information are unaffected by the use of visual scenes whereas false memories are increased when the theme is made more obvious.

The question that remains is how this developmental trend can be explained. Studies show that children are less able to extract meaning and less likely to automatically activate associative networks than adults. Perhaps when exposed to associatively related information in visual scenes, children would have fewer difficulties in accessing information in the knowledge base, information that make false memories more, rather than less, likely.

Another possibility is that because we used a recognition task in which participants were presented with contextual cues, this contextual cuing is similar to gist cuing in standard DRM research (Brainerd et al., 2008). Thus, in the current experiment, it is likely that the provision of meaning cues benefitted children’s gist extraction that could have affected the normal age-trend in spontaneous false memories. Alternatively, the contextual cue that we used could also have resulted in higher thematic activation, something that could have been more likely to increase children’s false memory rates than adults’. To examine these hypotheses more closely, we conducted Experiment 2 in which we (1) added an extra within-subject factor in which the context of the scenes was or was not cued, (2) included an extra age group (i.e., 11/12-year-olds) to test more thoroughly developmental trends of visual false memories, and (3) incorporated an extra visual scene to increase the variability of our stimuli.

Experiment 2

Method

Participants

Our sample consisted of 38 7/8-year-olds (mean age = 7.21, *SD* = 0.41, 20 boys), 34 11/12-year-olds (mean age = 11.41, *SD* = 0.50, 17 boys) and 24 adults (mean age = 21.17, *SD* = 2.90, 7 men). Children were recruited from elementary schools where they received parental consent. Adults were psychology undergraduates from Maastricht University. Children received a small gift for participating in this study. Students received course credits for their involvement.

Materials

The same visual scenes as in Experiment 1 were used (classroom, funeral, beach). However, we added an extra visual scene of a picture depicting two rooms with one room being monitored by the CIA (i.e., room surveillance).

Design and Procedure

This experiment used a 3 (Age: 7/8-year-olds, 11/12-year-olds, adults) x 2 (Cuing: Yes vs. No) mixed design with the latter factor being within-subject. Participants received the same instructions as in Experiment 1. However, they were presented with 4, instead of 3, visual scenes in a randomized order. Furthermore, during the recognition task, participants received context cuing on half of the presented pictures (i.e., by presenting the corresponding contextual cues along the items) and for the other two they did not receive any manipulation (i.e., without presenting the corresponding contextual cues).

Results and Discussion

Hi rates and false recognition

A repeated measures ANOVA was used to assess the effect of age and cuing on proportion recognition of studied items, false recognition, and unrelated items. For hit rates, there was no Age x Cuing interaction, $F(2,93) = 0.40$, $p = 0.68$). We did, however, find a significant main effect of age, $F(2,93) = 7.73$, $p < .001$, $?^2_g = .14$. Post-hoc Bonferroni tests showed that adults, $M = 0.80$, $SD = 0.18$, and 11/12-year-olds, $M = 0.81$, $SD = 0.15$, remembered significantly more correct items than the 7/8-year-olds, $M = 0.73$, $SD = 0.15$; both *p*s < .05; see Table 2. The 11/12-year-olds and adults, however, did not differ significantly from each other. The main effect of cuing was not significant, $F(1,93) = 0.00$, $p > .05$. An analysis of the corrected scores only found a significant age effect, $F(2,92) = 13.71$, $p < .001$, $?^2_g = .23$, with adults, no cuing: $M = 0.73$, $SD = 0.13$; cuing: $M = 0.79$, $SD = 0.10$, and older children, no cuing: $M = 0.74$, $SD = 0.11$; cuing: $M = 0.73$, $SD = 0.13$, remembering more correct information relative to the younger children, no cuing: $M = 0.65$, $SD = 0.14$; cuing: $M = 0.63$, $SD = 0.20$. The adults and older children did not differ statistically from each other.

Regarding false recognition, again there was no Age x Cuing interaction, $F(2,93) = 0.85$, $p = 0.54$. Our analysis did show a significant cuing effect, $F(1,93) = 4.15$, $p < .05$, $?^2_g = .04$, where for both children and adults, more false memories were reported when the context of the visual scenes was cued, $M = 0.27$, $SD = 0.11$, compared to when the context was not cued, $M = 0.25$, $SD = 0.12$. As in Experiment 1, there was a significant age effect, $F(2,93) = 9.55$, $p < .001$, $?^2_g = .17$. Post-hoc Bonferroni analyses revealed that the 7/8-year-olds, $M = 0.30$, $SD = 0.16$, had significantly higher false memory rates than adults, $M = 0.19$, $SD = 0.17$, $p < .001$, and higher false memory rates than the 11/12-year-olds but not significantly so, $M = 0.25$, $SD = 0.20$, $p = 0.06$. Although adults had lower false memory rates than the 11/12-year-olds, they did not differ significantly from each other, $p = .11$.

When we looked at the rates of unrelated items, although there was no Age x Cuing interaction, $F(2,92) = 0.96$, $p = 0.39$; 1 missing value, there was a significant age effect, $F(2,92) = 4.31$, $p < .05$, $?^2_g = .09$. Here, 7/8-year-olds, $M = 0.10$, $SD = 0.13$, recognizing more nonpresented, unrelated items than adults, $M = 0.04$, $SD = 0.16$, $p < .05$. The other age groups did not differ from each other. All other effects were not significant. Roughly similar patterns of results were detected for the transformed scores. Although the effect of cuing was almost reliable, $F(1,92) = 3.40$, $p = .07$, $?^2_g = .04$, the critical Cuing x Age interaction was not significant. Importantly, our analysis also showed that children had higher false memory rates than adults, $F(2,92) = 3.41$, $p = .04$, $?^2_g = .07$, with younger children, no cuing: $M = 0.36$, $SD = 0.14$; cuing: $M = 0.36$, $SD = 0.21$, falsely recollecting more details than the adults, no cuing: $M = 0.23$, $SD =$

0.19; cuing: *M* = 0.29, *SD* = 0.20.

As in Experiment 1, we found that younger children had more false memories than older children and adults when exposed to scene-like, visually presented related stimuli. What the present results underscore is that under certain conditions spontaneous false memories decrease with age. Importantly, the current experiment also demonstrates that cuing is an unlikely explanation for our developmental false memory trend. Specifically, our analysis did not detect a significant interaction between age and cuing, suggesting that the developmental trend remained intact even when the context of the visual scenes was not cued. We did show that overall cuing resulted in higher false memory rates than no cuing. This effect is in accordance with previous studies (Brainerd et al., 2008; Howe et al., 2009) and shows that context cuing is related to higher false memory rates. What probably happened when cuing was used is that the underlying meaning became more obvious, leading to elevated false memory levels for both children *and* adults. Thus, it does not seem to be the case that cuing mainly influenced children's false memory levels, but affected gist extraction or theme activation levels at all ages.

Alternatively, it is possible that when no cue was presented, individual items were considered to be more distinctive and possessed fewer relations with the context in which they were presented than when cuing did occur. Research shows that distinctiveness decreases false memory levels because participants encode and retrieve more the individual characteristics of an experience (e.g., Ghetti, Qin, & Goodman, 2002). In contrast, during cuing, participants were presented with the context in which the items were presented thereby increasing relational processing and false memory rates.

In contrast to Experiment 1, we found that hit rates also differed between age groups with children remembering fewer correct items than adults. Also, Experiment 2 showed that younger children recognized more nonpresented, unrelated items than adults, a finding that might be related to the fact that children remembered fewer correct items than adults. It is likely that the poor memory performance of the children made them more willing to accept nonpresented, unrelated items than adults. Indeed, it is well known that under many circumstances, young children are more likely to accept items as having been presented than older children and adults (i.e., a "yea-saying" bias; e.g., see Howe, 2007).

To summarize, the present experiment showed that children had higher false memory rates than adults and that cuing cannot account for this result. Hence, Experiment 3 focuses on whether our developmental trend effect is caused by the fact that the underlying theme of the visual scenes is easily identified. To test this in Experiment 3, we converted our visual scenes into story contexts and compared them with the original visual scenes in terms of false memory production.

Experiment 3

In Experiment 3, we investigated whether the underlying theme of our visual scenes is easily recognized, something that may lead to attenuated or reversed developmental trends in spontaneous false memories. In doing so, we compared the original visual scenes with story contexts in which the original visual scene items were embedded.

Method

Participants

In this experiment, 101 participants were involved (35 8/9-year-olds, mean age = 8.31, *SD* = 0.63, 18 boys; 32 11/12-year-olds, mean age = 11.25, *SD* = 0.44, 14 boys; 34 adults, mean age = 21.71, *SD* = 2.43, 7 men). Children had parental consent and received a small present for their participation. Adults received course credits.

Materials

Visual scenes. The exact same visual scenes were used as in Experiment 1 (classroom, funeral, beach).

Story contexts. The visual scene items of the classroom, funeral, and beach were embedded in three different story formats. The exact items as in the visual scenes were also mentioned in the stories. The three stories had roughly the same length in sentences. For the visual scenes and the story context, the same recognition task of Experiment 1 was used. However, because developmental patterns in false memories did not change when the themes of the scenes were cued or not, we did not cue the theme of the scenes/story context in this recognition task.

Design and Procedure

A 3 (Age: 8/9-year-olds, 11/12-year-olds, adults) x 2 (Condition: Visual scenes vs. Story) between-subjects design was used. Participants were randomly allocated to the Visual scenes (n = 52) or Story condition (n = 49). Participants in the Visual scenes condition received the same instruction as in the previous two experiments. However, in the Story condition, the stories were read to the participants by a female interviewer. Importantly, participants in the Story condition only received the stories and did not view any visual scene. Participants did not read the stories themselves as especially the younger children would experience difficulties with this and they would probably read slower than adults. After participants were presented with the visual scenes or stories, they received the same recognition task.

Results and Discussion

Hit rates and false recognition

We conducted a univariate ANOVA on our dependent variables. With regard to hit rates, there was no Age x Condition interaction, $F(2,95) = 2.75$, $p = .07$. We did find a significant age effect, $F(2,95) = 3.79$, $p = .03$, where post-hoc Bonferroni analyses showed that adults had significantly higher hit rates, $M = 0.79$, $SD = 0.09$, than the 8/9-year-olds, $M = 0.73$, $SD = 0.11$; see Table 3. There was no significant condition effect. For the transformed scores, we found no significant effects, all ps > .05.

For false recognition, there was no Age x Condition interaction, $p > .05$. However, we found a significant main effect of age, $F(2,95) = 10.99$, $p < .001$, $?^2_g = .18$. Post-hoc Bonferroni tests showed that the 8/9-year-olds, $M = 0.31$, $SD = 0.18$, and 11/12-year children, $M = 0.31$, $SD = 0.17$, had higher false recognition rates than adults, $M = 0.17$, $SD = 0.11$; both ps < .001. Younger and older children’s false recognition rates did not differ significantly. Our results also showed a significant condition effect, $F(1,95) = 17.90$, $p < .001$, $?^2_g = .16$, with more false memories evident in the visual scenes, $M = 0.32$, $SD = 0.17$, than in the story contexts, $M = 0.20$, $SD = 0.14$. When analyzing the unrelated items, we only found a significant age effect, $F(2,95) = 4.67$, $p < .05$, $?^2_g = .09$. Post-hoc tests showed that only the younger children, $M = 0.07$, $SD = 0.10$, had higher unrelated recognition rates than adults, $M = 0.02$, $SD = 0.04$, $p < .05$. When we looked at the transformed scores, we again found an attenuated trend of the standard developmental pattern in spontaneous false memories. So, although younger, $M = 0.74$, $SD = 0.25$, and older children, $M = 0.76$, $SD = 0.12$, had higher false recognition scores than adults, $M = 0.70$, $SD = 0.14$, this was not significant, $F(2,92) = 1.71$, $p = .19$; 3 missing values.

Similar patterns of findings were observed when focusing on the corrected scores. That is, a significant condition effect, $F(1,95) = 7.44$, $p < .01$, $?^2_g = .07$, was found with visual scenes eliciting the highest false memory rates. More interestingly, younger, $M = 0.26$, $SD = 0.21$, and older children, $M = 0.26$, $SD = 0.19$; $F(2,95) = 7.29$, $p < .001$, $?^2_g = .13$, had higher false memory rates than adults, $M = 0.12$, $SD = 0.11$.

Once more, we obtained clear evidence for our predicted developmental trend in spontaneous visual false memories. Specifically, Experiment 3 showed that for both the story contexts and visual scenes, children were more susceptible to false memories than adults. We also found that pictures led to higher false memory rates than story contexts, suggesting that themes are more easily accessed and activated with pictorial than story presentations.

Importantly, we found for both types of stimuli (i.e., visual scenes and stories) that children had higher false memory rates than adults. This suggests that the themes embedded in our visual scenes are more easily identified than when standard DRM word lists are presented. As children's theme recognition is less well developed than that of adults (Howe & Wilkinson, 2011), children should benefit more from this manipulation than adults, thereby leading to higher false memory rates for children than adults.

Also, we found that children remembered fewer correct items regardless of stimulus type. This result has often been corroborated in standard DRM research where children's correct memory performance is worse than adults' (e.g., Otgaar, Peters, & Howe, 2012). Our finding adds to the robustness of our primary result that shows that when exposed to visual, associatively related stimuli, children have higher false memory rates than adults. Furthermore, like Experiment 2, we also found that memories of unrelated items were more prevalent in children than in adults. Together, Experiments 2 and 3 suggest that children had a more lenient output criterion that made them more willing to accept even unrelated items, perhaps an indication of the oft-reported yea-saying bias (e.g., Howe, 2007).

General Discussion

The present experiments were conducted to assess a set of predictions concerning developmental trends in visual false memories using a novel paradigm. We presented children and adults with visual scenes in order to examine rates of true and false memory. Interestingly, we found a novel and hitherto unreported finding across three experiments – that is, when using scene-like visual stimuli that are associatively related, younger and older children evince *higher* false memory rates than adults. Unlike previous research using standard DRM-like stimuli, we found that when using scene-like visual materials, spontaneous false memories decrease, not increase, with age.

To test different explanations of this finding, we examined whether cuing (Experiment 2) might be related to this effect or whether the underlying theme in visual scenes is more easily identified (Experiment 3). Experiment 2 showed that our developmental false memory trend remained unperturbed by cuing – that is, the same developmental trend was obtained regardless of whether the context of the scene was cued during recognition. This suggests that cuing cannot account for why we found that children developed more false memories than adults when being presented with visual scenes. Importantly, this was not because the manipulation failed to work because we did show that cuing promoted the formation of false memories, regardless of age. Thus, when the context of the scenes was cued during the recognition task, both children and adults formed more false memories than when the context was not cued. This finding accords well with previous research (Brainerd et al., 2008; Odegard et al., 2008).

In Experiment 3, we compared false memory rates in visual scenes with story contexts in which associatively related items were embedded. That is, the change that we observed in the typical developmental trend might have arisen because the underlying themes in our visual scenes might have been quite easy to identify, resulting in increased and direct automatic activation of themes and their related concepts in children's associative networks. Previous research (Dewhurst et al., 2007; Howe & Wilkinson, 2011) has shown that this is also the case when DRM lists are embedded in story contexts, with developmental differences in false memories being significantly attenuated when story are presented. Because children experience more difficulties in automatically activating themes in memory, especially young children whose knowledge base contains concepts that are less well integrated or interconnected than older children's and adults' (e.g., Howe et al., 2009; Howe & Wilkinson, 2011), children's false memory formation should be enhanced when the underlying theme of information is made more obvious during encoding. The results from Experiment 3 confirmed this prediction. That is, we found that for both classes of stimuli (i.e., visual scenes, stories), false memory rates were significantly higher in children than in adults. So, indeed, it is likely that the theme of our visual scenes is easily identified thereby resulting in higher false memory rates in children than in adults, a pattern of findings consistent with predictions from AAT (Howe et al., 2009; Howe & Wilkinson, 2011).

An alternative explanation for our findings is that adults, but not children, relied more on verbatim than gist traces at output. Studies confirm that reliance on verbatim traces improves with age and that when verbatim traces are primed, trends in false memories may change (e.g., Brainerd, Reyna, & Kneer, 1995; Seamon, Kuo, Schlegel, Greene, & Goldenburg, 2000). For example, it has been shown that when studied items are presented before critical lures on recognition tests (verbatim priming), critical lures are more often rejected than unrelated distractors and this effect increases with age (Brainerd et al., 1995). If reliance on verbatim traces underlies our findings, then adults should exhibit better true and less false recognition than children, a pattern consistent with our findings. Indeed, a recent study by Holliday, Brainerd, and Reyna (2011) showed that developmental trends can be reversed when manipulations are used that lead participants to focus more on verbatim than gist traces. Specifically, they presented participants with the standard DRM task or a condition in which they received word fragments known to enhance verbatim memory. They found that in the standard DRM condition, the usual developmental trend was obtained, while in the other condition, developmental trends were reversed as they were in our current experiments. Our work also dovetails nicely with research showing that script-based errors are more pronounced in younger than older children (e.g., Erksine et al., 2001). It is possible that in these studies, the stimuli that were used may have triggered verbatim traces (for older participants) or contained obvious themes (for younger participants) that could have resulted in the observed developmental trend.

It is important to stress that our basic developmental false memory trend does not *seem* to accord with studies showing that spontaneous false memories increase with age (Brainerd et al., 2008). What is important to reiterate here is that theories such as FTT do lay out the principles about how false memories can increase (reliance on gist) or decrease (reliance on verbatim traces) with age. So, although our developmental trend might come as surprising, it is well anticipated by theoretical frameworks such as FTT and AAT (see below). Furthermore, studies on spontaneous false memories use a methodology that differs on certain dimensions from our methodology. First, in these studies, material is often constructed (e.g., DRM lists) in which the critical lures are backward associates of the list items. This was not the case in the present study. Here, the material is a pictorial version of the studies that have looked at the influence of schemas on memory performance (Brewer & Treyens, 1981) and in which the underlying theme of the scenes is easily recognized. Second, in studies using DRM lists, presentation of items is often successive whereas in this study, presentation of visual items was simultaneous. Nonetheless, our study provides additional evidence that different types of spontaneous false memories follow different developmental trajectories.

The main take-home message from our research is that spontaneous false memories do not always follow the same immutable developmental trend. Indeed, across three experiments, we found consistent evidence for a novel developmental trend in spontaneous false memories when using a visual false memory paradigm. That is, children were more likely to develop false memories than adults. These findings fit nicely with the predictions of AAT concerning the importance of theme identification in the production of spontaneous false memories. Similar to previously reported studies, it is likely that themes are more readily identified in visual scenes, something that increases children's false memory production more than adults'. Therefore, under certain well-prescribed conditions, the typical developmental trend in spontaneous false memories can be eliminated or even reversed.

Our findings have some interesting forensic implications. Historically, scientific evidence has indicated that children's testimony is more likely to be affected by false memories than adults' (Brainerd & Reyna, 2012; Ceci & Bruck, 1993). What the extant research on developmental trends in spontaneous false memories suggests is that this assumption is untenable when it comes to spontaneous false memories (Brainerd et al., 2008). What our studies reveal is that there are some perhaps more "real life" circumstances under which children may be more susceptible to false memories than adults. Specifically, using more "realistic" associatively related material, we found that like the developmental literature on suggestion-based false memories (Ceci & Bruck, 1993), children were more prone to false memories than adults. Of course, we simply used simplistic black-and-white visual scenes consisting of several related elements. The question that remains is whether developmental false memory trends would also be present when even more real life material is used. Indeed, in daily life, most of our experiences contain elements that are associatively related to each other. The cornerstone of our everyday experiences refers to situations with an obvious theme and relational context (e.g., going to the beach, visiting the supermarket). Our findings suggest that real life experiences that embody obvious contexts and themes might make children more, not less, susceptible to spontaneous false memories than adults. Indeed, in a recent study, we found that when using more realistic material (i.e., videos) that contained clear underlying themes, spontaneous false memories were also more likely to occur in children than adults (Otgaar, Howe, Peters, Sauerland, & Raymaekers, 2013).

Concluding Remarks

In the present article, we assessed the generality of developmental trends in spontaneous false memories by extending the paradigm traditionally used to evaluate these patterns. Specifically, we examined the role of context in the production of false memories in children and adults by using visual scenes or stories that contained associatively related information. Here, we found that a context that makes the underlying theme more obvious, especially for children, makes it easier for children to activate associatively related concepts in their knowledge base, increasing false memory rates. The result is that the standard developmental pattern in spontaneous false memories is attenuated and even reversed. That is, children produce more false memories than adults. These findings are in line with how AAT views how activity in associative networks spreads when a familiar context is available. That is, activation is more likely to spread between concepts that share a similar context than when no context is present.

At a more general level, although we mainly relied on AAT to generate our predictions, as indicated earlier, other theories (e.g., FTT) are able to predict the pattern of findings reported in this article. We do not wish to claim that AAT is the only theory available but we do believe that it is a promising theoretical framework, one that has guided our predictions in the current article, and that can help us understand the development of false memories. Indeed, it was because of the assumptions embedded in AAT that novel paradigms such as the one used here are beginning to emerge. In fact, additional paradigms have been developed based on AAT, ones that look at the positive effects of false memories (Howe, 2011), including their role is facilitating problem solving in children and adults (Howe, Garner, Charlesworth, & Knott, 2011).

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Table 1

Mean proportions and standard deviations (between parentheses) of hit rates, false recognition, not related, as a function of age (7/8-year-olds and adults; Experiment 1)

Age	Hit rates	False recognition	Not related
7/8-year-olds	.73 (.16)	.51 (.21)	.15 (.13)
Adults	.69 (.09)	.31 (.15)	.11 (.09)

Table 2

Mean proportions and standard deviations (between parentheses) of hit rates, false recognition, not related, as a function of age (7/8-year-olds and adults; Experiment 2) and gist cuing

	Hit rates		False recognition		Not related	
Age	Gist	No gist	Gist	No gist	Gist	No gist
7/8-year-olds	.73	.73	.31	.30	.10	.09
	(.13)	(.13)	(.12)	(.11)	(.14)	(.11)
11/12-year-olds	.80	.81	.27	.23	.07	.07
	(.10)	(.09)	(.08)	(.11)	(.09)	(.09)
Adults	.81	.79	.20	.18	.02	.05
	(.09)	(.11)	(.12)	(.11)	(.06)	(.07)

Table 3

Mean proportions and standard deviations (in parentheses) of hit rates and false recognition, recognition of unrelated items as a function of age (7/8-year-olds and adults; Experiment 2) and condition (visual scenes vs. story contexts)

	Hit rates		False recognition		Not related	
Age	V	S	V	S	V	S
8/9-year-olds	.73	.73	.37	.22	.09	.06
	(.12)	(.10)	(.18)	(.15)	(.10)	(.11)
11/12-year-olds	.79	.72	.39	.23	.07	.04
	(.10)	(.11)	(.15)	(.15)	(.08)	(.07)
Adults	.77	.82	.18	.15	.02	.01
	(.09)	(.09)	(.11)	(.11)	(.05)	(.03)

Note: V = Visual DRM scenes, S = Story context

Figure 1. Hypothetical knowledge base network containing individual concepts, theme nodes, and a subset of potential activation pathways. From Howe and Wilkinson (2011). Used by permission.