Age differences in the contribution of recollection and familiarity to false-memory formation: a new paradigm to examine developmental reversals

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Abstract

Using a new method for studying the development of false-memory formation, we examined developmental differences in the rates at which 6-, 7-, 9-, 10-, and 18-year-olds made two types of memory errors: backward causal-inference errors (i.e. falsely remembering having viewed the non-viewed cause of a previously viewed effect), and gap-filling errors (i.e. falsely remembering having viewed a script-consistent event that was not actually witnessed). Previous research suggests that backward causal-inference errors are supported by recollection, whereas gap-filling errors are supported by familiarity. We hypothesized that age differences in these errors would parallel the developmental trajectories of these processes. As predicted, age-related increases in backward causal-inference errors were observed, while gap-filling errors were age-invariant, suggesting that recollection-based memory distortions increase with age while familiarity-based memory distortions are relatively stable from middle childhood through adulthood.

Introduction

Individuals frequently form false memories (e.g. Brainerd & Reyna, 2005; Roediger & McDermott, 1995). Understanding how this propensity changes over the course of development has implications for both theory (e.g. in identifying the mechanisms underlying false-memory formation and its development; e.g. Howe, 2006; Lindsay, Johnson & Kwon, 1991; Reyna & Brainerd, 1998) and practice (e.g. in evaluating whether children can be relied upon as reliable eyewitnesses; Castelli, Goodman, Edelstein, Mitchell, Alonso, Lyons & Newton, 2006; Ceci & Bruck, 1995; Thierry & Spence, 2002).

Previous research has outlined some of the conditions under which developmental decreases or increases in false-memory formation are observed. When false memories arise as a function of social pressure to endorse a memory (e.g. Bruck & Ceci, 1999; Ceci & Bruck, 1993), or failure to correctly attribute the source from which information was acquired (e.g. Lindsay et al., 1991; Roberts & Blades, 2000), the propensity to form false memories decreases with age. However, when false memories arise as a function of individuals falsely remembering the (non-presented) underlying meaning or ‘gist’ of events, developmental increases in false memory are observed (e.g. Brainerd, Reyna & Ceci, 2008; Brainerd, Reyna & Forrest, 2002; Howe, Cicchetti, Toth & Cerrito, 2004; but see Ghetti, Qin & Goodman, 2002). This result has been called developmental reversal (e.g. Brainerd et al., 2008) because it counters the general intuition that memory ought to improve over the course of childhood. Overall this body of research has provided clear evidence that the propensity to form false memories increases or decreases with age as a function of the processes underlying the memory distortion, and how these processes change over the course of development.

Nevertheless, important questions remain about the effects of age-related changes in the operation of basic memory functions (i.e. memory processes supporting individuals’ ability to recognize an item as one that has been previously encountered) on false-memory formation. There is evidence indicating that recognition memory is supported by two distinct processes, recollection and familiarity (Yonelinas, 1994, 1999). Recollection is the process that allows for the retrieval of qualitative details about the context in which an item was originally encountered (e.g. ‘I met this person at Sue’s dinner party last week’). Familiarity is the process allowing for the experience of a general sense of ‘oldness’ about an item, in the absence of retrieving qualitative details.
details about the encoding experience (e.g. ‘I met this person before, but I do not remember when or where’). Previous research indicates that these processes support both true and false memories (Brainerd, Wright, Reyna & Mojardin, 2001; Lampinen, Odegard, Blackshear & Toglia, 2005), and that these memory processes follow distinct developmental trajectories: Whereas familiarity stabilizes in childhood, recollection continues to develop from childhood to adulthood (Brainerd, Holliday & Reyna, 2004; Ghetti & Angelini, 2008). It logically follows that age-related differences in these processes should result in age-related differences in memory distortions arising from the two processes, such that familiarity-based memory distortions should be relatively age-invariant, while recollection-based distortions should increase from childhood through adulthood. The present research tested this hypothesis.

Previous research using the Deese Roediger-McDermott paradigm (DRM; Deese, 1959; Roediger & McDermott, 1995) has provided some insight into the role of recollection in false-memory formation. This paradigm involves the study of word lists of semantic associates (e.g. yawn, slumber, rest) whose theme is captured in a word (i.e. sleep) that is never presented during the study (i.e. the critical lure). Upon studying these lists, participants make old/new recognition judgments of actually studied words, critical lures, and other lures that are not semantically associated with the studied materials. Adult participants are typically as likely to falsely recognize critical lures as they are to correctly recognize studied words (Roediger & McDermott, 1995), mostly because, by connecting the meaning of the studied words, they encode the critical lure along with the study items. Of importance, erroneous recognition of the critical lure is typically accompanied by vivid experiences of false recollection, as opposed to a general sense of familiarity (Brainerd et al., 2004; Brainerd, Reyna & Mojardin, 1999; Roediger & McDermott, 1995).

Typically, false memories for critical lures increase with age (e.g. Brainerd et al., 2002), suggesting that age-related increases in recollection may contribute to age-related increases in false-memory formation. However, firm conclusions cannot be drawn, because age-increases in memory errors on the DRM paradigm may also arise from age-related increases in children’s ability to appreciate semantic relations among items on the lists (e.g. Brainerd et al., 2008; Howe, 2008; Sloutsky & Fisher, 2004).

To truly examine the effects of age-related increases in recollection on false-memory formation we used a paradigm for studying false memories that has never been used in developmental research. The backward causal-inference paradigm was originally developed by Hannigan and Reinitz (2001) and affords the opportunity to test for age differences in memory distortions, but does not rely on the ability to appreciate the overall theme of a list across multiple items. In this paradigm, adults viewed a series of photographs belonging to a common script (e.g. eating at a restaurant). This series included photographs of effects (e.g. wiping up water from a table) of non-presented causes (e.g. knocking over a glass of water). After a delay, participants completed an old/new recognition test that included photographs depicting causes (e.g. knocking over a glass of water) whose effect photograph had been viewed during encoding (e.g. wiping up water from a table) as well as cause photographs (e.g. finding a hair in one’s soup) whose effect photograph (e.g. complaining to the waiter) had not been viewed. Similar to the DRM effect, participants reported high confidence in their false memories for having viewed the cause photographs of events whose effect photograph had been viewed during encoding (i.e. backward-causal-inference errors).

Thus, in the backward causal-inference paradigm, false memories are observed even though participants view only one photograph (i.e. the effect photograph), which specifically induces them to err. This type of error is assumed to arise because, during encoding, when presented with an effect photograph, participants make an inference about the previously occurring cause that must have led to the effect (although this cause photograph was not actually viewed). Later during the test, participants falsely recollect having viewed the cause, although in reality they only inferred the cause (Hannigan & Reinitz, 2001). Indeed, when participants were asked to characterize their subjective memory experience by providing remember/know judgments (Tulving, 1985), Hannigan and Reinitz (2001, Experiment 3) showed that backward causal-inference errors were more likely to be accompanied by ‘remember’ responses than gap-filling errors (i.e. false recognition of events that are highly consistent with a well-known script from which several events were actually encountered). Gap-filling errors were more likely to be associated with ‘know’ responses. This finding led the authors to conclude that recollection supports backward causal-inference errors and familiarity supports gap-filling errors.

We note that Hannigan and Reinitz (2001) also tested the possibility that individuals would form false memories for forward causal-inferences (i.e. falsely recognizing the effect of a witnessed cause), but they observed that individuals rarely committed this error. Other research suggests that individuals are more likely to draw backward inferences than forward inferences (Grässer, Singer & Trabasso, 1994; Schmalfhofer, McDaniel & Keefe, 2002), perhaps because the former class of inferences is necessary in order to comprehend a narrative, while the latter is not (Grässer et al., 1994; McKoon & Ratcliff, 1992). Although it is conceivable to design conditions that would promote forward causal-inference errors (McDaniel, Schmalfhofer & Keefe, 2001), we elected to focus only on backward-inference errors in the present study, because the recollective nature of this error has been previously documented.
In the present research we adapted Hannigan and Reinitz’s paradigm for use with children to examine how the rates of backward causal-inference (i.e. recollection-based) and gap-filling (i.e. familiarity-based) errors differed developmentally, between the ages of 6 and adulthood. We selected this age range because it represents a period during which recollection develops substantially, while familiarity is relatively stable (Brainerd et al., 2004; Ghetti & Angelini, 2008). We elected to examine multiple age groups within this range to have the opportunity to closely explore the developmental trajectory of recollection- and familiarity-based false-memory formation.

Six-, 7-, 9-, 10-, and 18-year-olds viewed a series of photographs belonging to four common scripts. Each series included an effect photograph whose cause photograph was not presented. After a delay, participants completed a recognition test that included old and new script-consistent and script-inconsistent photographs, as well as cause photographs, whose effect photograph had been seen, and cause-control photographs, whose effect photograph had not been seen. Thus memory distortion type was varied within participants.

We predicted that age-related increases would be observed in recollection-based (i.e. backward causal-inference) errors, but that familiarity-based (i.e. gap-filling) errors would be relatively age-invariant. To test this hypothesis further, we collected confidence ratings from participants. Although one can be quite confident about memories deriving from familiarity, research indicates that recollection typically generates the most confident responses (Yonelinas, 2001). Thus, backward causal-inference errors should be accompanied by higher confidence ratings than gap-filling errors in adults and older children (who are expected to rely upon recollection in making the former error and to rely upon familiarity in making the latter error), but not in younger children (who are expected to rely on familiarity for all memory decisions). This pattern of results would be consistent with the view that age-related increases in recollection contribute to age increases in the propensity to form false memories.

Our predictions are based on what is known about the developmental course of recollection and familiarity. However, these processes do not occur in a vacuum. As such, the operation of additional processes that specialize in opposing false-memory formation (e.g. recollection rejection, Brainerd & Reyna, 2002; metamemory-based rejection strategies, Ghetti, 2008a) may modify the predicted trajectories. For example, these processes are known to improve with age, and are more likely to successfully contrast familiarity-based false memories than recollection-based false memories. Thus, a slight age-decline instead of age invariance may be observed for familiarity-based errors. Nevertheless, to the extent that distinct developmental trajectories are observed in recognition and confidence data for the two error types, results will underscore the nature of false-memory formation as resulting from multiple processes and leading to multiple developmental pathways.

Method

Participants

Participants included 120 individuals, equally divided among five age groups: 6-year-olds (M = 6.51 years, range = 6.01–6.91); 7-year-olds (M = 7.67 years, range = 7.17–8.08); 9-year-olds (M = 9.45 years, range = 9.08–9.92); 10-year-olds (M = 10.53 years, range = 10.08–10.92), and 18-year-olds (M = 18.6 years, range = 18.2–18.6). These age groups were selected because they span a period of development during which familiarity stabilizes whereas recollection continues to develop (Brainerd et al., 2004; Ghetti & Angelini, 2008). Critically, the ability to make inferences regarding the kind of cause–effect relationships examined here is stable during this period (Hudson & Nelson, 1983; Principe, Guiliano & Root, 2008; Schmidt & Paris, 1978). Gender was evenly balanced in all age groups. All participants were from middle-class families, of European-Caucasian descent, and attended public elementary and high schools in northern Italy. Written consent was obtained from parents of minors prior to participation.

Materials

Stimuli included color photographs belonging to one of four scripts: eating at a restaurant, getting up in the morning, going grocery shopping, and being in the classroom. For each script, 20 photographs were created: 16 photographs depicting typical events in the sequence, and two pairs of photographs depicting cause (e.g. someone removing an orange from the bottom of a stack)–effect (e.g. oranges on the floor of a grocery store) sequences. Table 1 provides an example of each type of photograph for each of the four scripts. The stimuli set also included eight photographs inconsistent with any of the scripts. All photographs were created for the purposes of this study.

Procedure

Participants were tested individually at their schools. For each of the four scripts, participants incidentally encoded 12 of the 16 photographs of the sequence in logical order. Participants were told to pay attention to the pictures. Within each script sequence, they also viewed an effect photograph (e.g. oranges on the floor of a grocery store) without viewing the corresponding cause photograph (e.g. someone removing an orange from the bottom of a stack). Photographs were presented on a computer monitor. Each photograph was presented for 2 seconds, with a 3-second interval between presentations. A 12-second interval was
included between scripts. Script order was counterbalanced. Two script-inconsistent photographs were shown at the beginning and end of the encoding phase to reduce primacy and recency effects. Overall, the encoding phase lasted approximately 5 minutes.

After a 15-minute filler task, participants completed an old/new recognition test. The test included 48 photographs and consisted of (a) 16 old photographs (four from each script); (b) four old script-inconsistent photographs; (c) four new photographs depicting causes whose effect had been seen (i.e. cause photographs; one from each script); (d) four new photographs representing causes whose effect had not been seen (i.e. cause-control photographs; one from each script); (e) 16 new script-consistent photographs. Photograph status as old/new, and cause/cause-control was counterbalanced. The test photographs were presented in a random order.

Immediately after providing each recognition judgment, confidence ratings were collected using a 3-point scale (very sure, kind of sure, not sure at all). Following the procedures of Ghetti et al. (2002), the scale was anchored by photographs of a child of the same sex as the participant making a confident expression and a doubtful expression. A dot representing a moderate level of confidence was placed directly between the two photographs. Children were instructed that they should indicate the low point on the scale (i.e. the child making a confident expression) when they were ‘very sure’, that they should touch the dot in the middle point when they were ‘kind of sure’, and that they should indicate the low point on the confidence scale (i.e. the child making a doubtful expression) when they were ‘not sure’. For data analysis, these points were coded as 2, 1, and 0, respectively. The overall duration of the task (including encoding, delay, and test) was approximately 25 minutes.

Results

The main dependent variables were the rates at which individuals made backward causal-inference and gap-filling errors, and the confidence with which individuals endorsed the two types of memory errors. In the following sections we first report analyses of memory performance and then confidence ratings. Post-hoc tests are reported as significant at $p < .05$ using Bonferroni’s correction.

Recognition rates

Hit rates were comparable across age groups (Table 2a). No significant age differences were observed in raw hit rates, $F(4, 115) = 1.15$, $p = .33$, $\eta_p^2 = .03$, or corrected hit rates (i.e. raw hits minus false alarms to script-inconsistent distracters), $F(4, 115) = 1.15$, $p = .34$, $\eta_p^2 = .03$.

Following the procedures of Hannigan and Reinitz (2001), two corrected indices of false recognition were created. Backward causal-inference error rates were calculated by subtracting false alarms to cause-control distracters from false alarms to cause distracters. These error rates thus reflected false memories for the non-presented causes of previously viewed effect photographs, controlling for the familiarity of these distracters. Gap-filling error rates were calculated by subtracting false alarms to script-inconsistent distracters from false alarms to script-consistent distracters. These error rates thus reflected false memories for non-presented but script-consistent photographs arising from the familiarity of these distracters. We chose to use these corrected recognition indices for their simplicity and because they do not make assumptions about the normality of the underlying distribution of memories that our relatively small number of items would likely violate (e.g. $d’$; MacMillan & Creelman, 2005). Nevertheless, the same patterns of results are found when $d’$ and its non-parametric counterpart $A’$ are used (Snodgrass, Levy-Berger & Haydon, 1985).

Error rates are reported in Figure 1. Table 2b reports false-alarm rates (from which the corrected error scores were computed). Corrected false-alarm rates were entered into a 5 (Age: 6-years-old vs. 7-years-old vs. 9-years-old vs. 10-years-old vs. 18-years-old) $\times$ 2 (False-memory effect: Backward causal-inference vs. Gap-filling) mixed ANOVA. As predicted, a significant interaction between age and false-memory effect, $F(4, 115) = 3.79$, $p < .01$, $\eta_p^2 = .12$, was observed. Age-related increases in the formation of backward

<table>
<thead>
<tr>
<th>Script</th>
<th>Script-consistent photograph</th>
<th>Cause (and cause-control) photograph</th>
<th>Effect photograph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eating at a restaurant</td>
<td>Ordering dinner</td>
<td>Knocking over a glass of water</td>
<td>Wiping up water from a table</td>
</tr>
<tr>
<td>Getting up in the morning</td>
<td>Getting dressed</td>
<td>Putting cereal back in the kitchen cabinet</td>
<td>Getting a finger trapped in the cabinet</td>
</tr>
<tr>
<td>Going grocery shopping</td>
<td>Selecting a shopping cart</td>
<td>Taking an orange from the bottom of the stack</td>
<td>Oranges all over the floor</td>
</tr>
<tr>
<td>Being in a classroom</td>
<td>Raising a hand to answer a question</td>
<td>Leaning backward from the desk in one’s chair</td>
<td>Falling down</td>
</tr>
</tbody>
</table>

Table 1 Examples of events depicted in photographs by script and stimulus type

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causal-inference errors were observed, $F(4, 115) = 3.19$, $p < .05$, $\eta^2_p = .10$. Bonferroni tests revealed that only the difference between 6-year-olds’ backward causal-inference error rate and that of 9-year-olds and adults reached conventional levels of statistical significance. However, all age groups but 6-year-olds obtained a backward causal-inference error score which was significantly different from zero, indicating that this error was present from age 7 on.

A closer examination of the false-recognition rates with a 5 (Age: 6-years-old vs. 7-years-old vs. 9-years-old vs. 10-years-old vs. 18-years-old) × 3 (Distracter type: Cause vs. Cause-control vs. Script-inconsistent) ANOVA revealed a significant age by distracter type interaction, $F(8, 230) = 2.43$, $p < .05$, $\eta^2_p = .08$. Six-year-olds were significantly more likely to falsely recognize cause and cause-control distracters than script-inconsistent distracters. In contrast, older children and adults were more likely to commit false alarms to cause photographs than cause-control and script-inconsistent distracter photographs, which did not differ (Table 1).

A different pattern of results was observed for gap-filling errors. No age-related differences were observed in the rate of these errors, $F(4, 115) = 1.77$, $p = .14$, $\eta^2_p = .06$. This error was reliably observed in all age groups.

Confidence ratings
A preliminary analysis was performed to verify appropriate use of the confidence scale across ages. Specifically, confidence ratings associated with hits were compared to those associated with misses (i.e. incorrect ‘no’ responses to photographs that had been previously seen) in a 5 (Age: 6-years-old vs. 7-years-old vs. 9-years-old vs. 10-years-old vs. 18-years-old) × 2 (Response type: Hit vs. Miss) ANOVA. Appropriate use of the scale was inferred if hits received higher confidence ratings than misses. Results were consistent with this expectation; across age groups, hits were endorsed more confidently, $M = 1.76$, than misses, $M = 1.29$, $F(4, 104) = 92.05$, $p < .001$, $\eta^2_p = .47$. No significant interaction with age was found.

Thus, confidence ratings associated with backward causal-inference and gap-filling errors (Figure 2) were analyzed to obtain further evidence of age differences in the contributions of recollection and familiarity to the two error types. Confidence ratings associated with false alarms to cause photographs whose effect photograph had been seen (i.e. backward causal-inference errors) and to script-consistent photographs (i.e. gap-filling errors) were compared in a 5 (Age: 6-years-old vs. 7-years-old vs. 9-years-old vs. 10-years-old vs. 18-years-old) × 2 (False-memory effect: Backward causal-inference vs. Gap-filling) ANOVA. A significant age by false-memory effect interaction was observed, $F(4, 96) = 2.59$, $p < .05$, $\eta^2_p = .10$ (Figure 2). Bonferroni post-hoc tests revealed that whereas adults were more confident when making backward causal-inference errors compared to gap-filling errors, the opposite was true for 6-year-olds, $p_s < .05$. No significant difference between confidence in the two error types was evident in the other age groups.

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with the exception of a trend for 10-year-olds, $p = .09$, to exhibit a pattern similar to that of adults.

**Discussion**

The goal of the current research was to examine the effects of age-related differences in the operation of basic memory processes on the development of false-memory formation. To this end, we adapted for the first time a paradigm previously used in adult research for studying the development of false-memory formation in children. Our central hypothesis was that recollection-based false-memory formation increases during childhood, whereas familiarity-based false-memory formation would be relatively stable during this period.

Results were consistent with the predictions. Backward causal-inference errors increased with age, while gap-filling errors were age-invariant. Previous research indicates that the ability to make causal inferences for simple cause–effect relations such as those used in this research (e.g. Principe et al., 2008; Schmidt & Paris, 1978; Schmidt, Paris & Stober, 1979) and in script knowledge for common routines (Hudson & Nelson, 1983) does not improve in the age range selected here. Thus, we consider it unlikely that our results merely reflect developmental differences in causal reasoning. Instead, it appears that age-related increases in recollection contribute to age-related increases in recollection-based memory distortions.

Consistent with this conclusion, we found that 6-year-olds did not show backward causal-inference errors, whereas the older groups did. Further, adults were significantly more likely to exhibit this effect than the youngest children. We note that this result did not emerge because the youngest group endorsed fewer cause distracters than the older age groups. Instead, 6-year-olds’ failure to demonstrate this type of error was due to the fact that they incorrectly endorsed a higher number of cause-control distracters, relative to the older age groups. In fact, the youngest age group committed comparable false alarms to cause, cause-control, and script-consistent (i.e. gap-filling) distracters. This kind of pattern is consistent with the frequently observed age increases in the DRM effect: It is not unusual for age-related increases in the DRM effect to depend not on age-related increases in false recognition of the critical lures (which is often age-invariant in middle childhood), but on an age-related reduction in false alarms for the unrelated lures (e.g. Lampinen, Watkins & Odégard, 2006), which suggests an increased specificity in false-memory effects with development.

Combined with 6-year-olds’ low levels of false alarms for script-inconsistent distracters, our results suggest that the youngest group was primarily relying on the familiarity of test items to make recognition decisions (and memory errors). Six-year-olds likely experienced a global sense of familiarity for cause and cause-control distracters because both photograph types were conceptually consistent with events that occur in a particular script (e.g. a person could conceivably knock over a glass of water at their table while eating at a restaurant) and perceptually similar to target items (e.g. the people, table, and surrounding restaurant looked the same in distracter and target photographs). This global sense of familiarity led children to falsely recognize cause and cause-control distracters, when neither distracter type had been previously encountered.

In contrast to 6-year-olds, older children and adults showed a different pattern of results. They were more likely to commit false alarms to cause photographs than cause-control photographs. When presented with cause photographs, older children and adults may have falsely recollected these photographs, confusing the photographs for the causal inferences they had made when the corresponding effect photographs had been viewed during encoding. However, older children and adults successfully rejected cause-control photographs (because no such inference had been made during encoding as the corresponding effect photograph had not been studied). Older children and adults were likely able to interpret their lack of memory for the events depicted in cause-control distracters as evidence that these photographs had not been encountered, despite their familiarity. This would account for older children’s and adults’ rates of false alarms to cause-control distracters being comparable to those of script-inconsistent distracters.

We note that the substantial stability in the magnitude of the backward causal-inference effect from age 7 on may seem difficult to reconcile with the fact that recollection is known to develop during this period. However, it is also known that age-related increases in false-memory during middle childhood are counteracted by developmental increases in opposing mechanisms (e.g. recollection rejection; Brainerd, Reyna, Wright & Mojardin, 2003; metamemory rejection strategies; Ghetto, 2008a; source-monitoring skills; Roberts & Blades, 2000) which might result in little or no net change in age differences in false-memory formation (Ghetto, 2008b). Indeed, even with the DRM paradigm, stability is often observed during this period (Brainerd et al., 2002; Carneiro, Albuquerque, Fernandez & Esteves, 2007; Dewhurst, Purglove & Lewis, 2007; Metzger, Warren, Shelton, Price, Reed & Williams, 2008). The dynamic interplay during development between mechanisms that support false memory and those that oppose it should be examined in future research.

The pattern of results obtained with confidence ratings provides converging evidence about differences in the relative contribution of recollection and familiarity to false-memory formation across age groups. Young children’s confidence ratings likely reflected the familiarity of the test items (e.g. Yonelinas, 1994). Six-year-old children reported higher confidence in their endorsement of script-consistent distracters than their endorsement of cause and cause-control distracters, likely because the former class of photographs depicted
events that are arguably more common to a script, and thus more familiar than the latter classes of distracters.

Older children’s and adults’ pattern of confidence ratings suggest that their subjective experience of making the memory distortions was different from that of 6-year-olds. Adults were more confident in their backward causal-inference errors than their gap-filling errors, consistent with the idea that these false memories were supported by recollection. An analogous, although attenuated, pattern was exhibited by the oldest children (i.e. 10-year-olds). In contrast, confidence ratings provided by 7-, 8- and 9-year-olds did not significantly differ between backward causal-inference and gap-filling errors, suggesting that the former error was not subjectively more compelling than the latter as it was for adults and, in part, 10-year-olds. Thus, even though the likelihood of falling for backward causal-inference errors does not seem to increase between age 7 and adulthood, results concerning confidence ratings seem to indicate that the subjective experience of falsely recollecting non-presented causes becomes increasingly vivid, as recollection continues to develop.

In sum, our results suggest that age differences in recollection and familiarity contribute to age differences in false-memory formation. Six-year-olds appear to form familiarity-based, but not recollection-based, false memories. As recollection develops, however, the propensity to form recollection-based false memories appears to increase. These findings highlight the multifaceted nature of false-memory development, in which the mechanisms of change include age-related improvements in the processes supporting both the formation and rejection of false memories. To fully understand the multiple pathways to false-memory development, future research will need to increasingly employ new paradigms and measurement methods to account for the complexity of the phenomenon. The current research represents an important first step in this direction.

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