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The 'Magical' Effect of Integration on Event Memory

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Summary: Only a handful of studies have extended our understanding of retrieval induced forgetting (RIF) during development and even fewer have tested for RIF effects outside word-list paradigms. The purpose of these experiments was to: (i) examine how partial retrieval of a witnessed event would impact subsequent retrieval of that event in school-aged children; and (ii) examine the robustness of semantic integration as a boundary condition on RIF. Two experiments were conducted using the three traditional phases of the RIF paradigm: study phase, practice phase, and test phase. We found clear evidence of RIF in event memory. There was also evidence of the robust impact that integration instructions have on minimizing RIF. Integration appears to not only have a dampening effect on RIF, but integration instructions may also influence how children process all aspects of an experience, regardless of whether a person is passively or actively part of the experience.Copyright © 2016 John Wiley & Sons, Ltd.

It is well established that repeated retrieval of a memory can improve future recall of rehearsed components (Anderson, Bjork, & Bjork, 1994). However, repeated retrieval can also come at a cost—especially when only part of a memory is initially retrieved. The act of retrieving memories can cause the subsequent forgetting of other, related memories (Anderson, 2003; Anderson et al., 1994). This effect, called retrieval induced forgetting, is well documented in the experimental literature (e.g., Anderson et al., 1994; Hicks & Starns, 2004). The problems associated with partial retrieval of a memory have pragmatic implications. In forensic settings, for example, partial retrieval in the form of cued recall questions is common practice during investigative interviews with both adult and child witnesses (Fisher, 2010; Lamb, Orbach, Hershkowitz, Esplin, & Horowitz, 2007). Only a handful of studies have attempted to extend our understanding of retrieval induced forgetting developmentally and, of those, even fewer have tested for retrieval-induced forgetting effects outside the word-list paradigm (e.g., Aslan & Bäuml, 2010; Ford, Keating & Patel, 2004; Phenix & Price, 2012). The aim of the present work was to add to the existing literature on retrieval induced forgetting in children by examining if partial retrieval of a complex event could impact subsequent retrieval of unpracticed elements of that event.

RETRIEVAL INDUCED FORGETTING

The most common method used to demonstrate retrieval-induced forgetting involves participants studying lists of words from various semantic categories. Anderson and colleagues (1994) first used this method by conducting a series of experiments that each included three phases: a study phase, a practice phase, and a final testing phase. During the study phase, participants were presented with semantically connected word pairs containing eight broader categories (e.g., *FRUIT*) and six individual exemplars of that category (e.g., *orange, apple*). During the retrieval practice phase, participants practiced retrieving from memory half of the categories and half of the exemplars from those categories using a word-stem cue (e.g., say 'Orange' when presented with *FRUIT: or___*). Practiced items were identified as Rp+ (Retrieval practiced category, item practiced) and items from the same category that were not practiced (e.g., *FRUIT*: *apple*) were identified as Rp− (Retrieval practiced category, item unpracticed) while exemplars that were from an unpracticed category were identified as Nrp (No retrieval practice category; e.g., DRINKS: *cola*). During the final testing phase, participants were asked to retrieve all of the studied exemplars in each of the studied categories. Anderson and colleagues (1994) found that the unpracticed items from the practiced category (Rp−; *apple*) were not remembered as well as items that were practiced (Rp+; *orange*). Much more interesting than this commonly observed practice effect was the observation that Rp− items (e.g., FRUIT: apple) were less likely to be retrieved when compared to the baseline category (Nrp; DRINKS: *cola*) that had no practiced items. This Rp− and Nrp difference in recall is the retrieval-induced forgetting effect. Anderson et al. (1994) argued that this difference is a result of competition between items in memory. When items are closely related to the retrieval cue (e.g., apple and orange both belong to the FRUIT category), competition ensues because only one memory can be retrieved. The memory that is most highly activated (e.g., the target memory) suppresses its competitors (e.g., FRUIT: apple) and thereby ensures it is efficiently retrieved because of its much higher activation level. This retrieval process comes at a cost: subsequent access to the previously suppressed memory items because more difficult (Anderson, 2003; Anderson et al., 1994; Bjork, 1989). There is, however, evidence suggesting that retrieval-induced forgetting is subject to an important boundary condition, called integration, that can minimize or even eliminate RIF (e.g., Goodmon & Anderson, 2011).

Integration as a boundary condition

Integration involves the formation of strong interconnections between items and has been found to reduce or even eliminate the retrieval-induced forgetting effect (e.g., Anderson & McCulloch, 1999; Baüml & Hartinger, 2002; Goodmon & Anderson, 2011). According to Goodmon and Anderson (2011), the extent of RIF is dependent upon the associations

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a person makes between competing items to be recalled. A threshold of association must be met to ensure that competition between items can be created; however, increasing the strength of the association to a high degree can also eliminate RIF. When the association between items is particularly strong, as in the case of high levels of semantic integration, partial retrieval will not impair recall of related items because these items are no longer distinct competing elements but instead are aspects of a larger whole (multipart representation; Anderson & McCulloch, 1999). Integration instructions are typically introduced with explicit instructions (e.g., Anderson & McCulloch, 1999) or learning strategies (Anderson & Bell, 2001) to cue participants to think about the to-be-recalled items in a coherent way. Beyond this, we do not have a complete understanding of the relationship between integration and forgetting (Carroll, Campbell-Ratcliffe, Murnane & Perfect, 2007).

RETRIEVAL INDUCED FORGETTING IN FORENSIC CONTEXTS

Understanding how partial retrieval affects future remembering is relevant in forensic contexts (Camp, Wesstein & Bruin, 2012). Each year there are estimated to be more than 3 million reports of suspected child maltreatment in the United States (U.S. Department of Health and Human Services, 2015) and over 73 000 violent crimes committed against children are reported annually in Canada (Statistics Canada, 2010). Moreover, more than half of all self-reported spousal violence occurs in the presence of a child witness in Canada (Statistics Canada, 2009). A child victim or witness is often the only source of information about the event (Bruck & Ceci, 1999; Lamb, Sternberg, & Esplin, 1994). As such, these children are likely to be asked to provide details of a crime several times (see Malloy, Lyon, & Quas, 2007). A child may be asked to provide details immediately after a crime to an investigating officer, again at the police station or hospital, in court, and when discussing the event with therapists or family. Right from the first instance of retrieval, a child may be asked to recall only parts of an experience—those which the interviewer/questioner deems to be most important for investigation. For example, in a best-practice interview, an investigator should follow up an opened-ended response with cued questions that reference a specific detail or incident, such as ‘Earlier you mentioned a [person/object/action invitations]; Tell me more about that’ or ‘wh’ prompt questions (e.g., what, where, when; Lamb et al., 2007).

Information that is repeatedly recalled will be best remembered in the future, as the rehearsal helps to inoculate against forgetting (Dent & Stephenson, 1979). However, being asked to recall only specific parts of an event may negatively affect a child’s ability to recall the entire event over an extended delay (Phenix & Price, 2012). Efforts to explore the impact of repeated, partial retrieval in forensic contexts were first made by Shaw, Bjork, and Handel (1995). Those authors found that, even when no misinformation was provided to witnesses, repeated interrogation of specific details detracted from the witness’s memory of related, unpracticed details. Since then, there have been several studies that have found evidence of RIF in adult eyewitnesses (Camp et al., 2012; Garcia-Bajos, Migueles, & Anderson, 2009; MacLeod, 2002; Macrae & MacLeod, 1999; Migueles & Garcia-Bajos, 2007; Saunders & MacLeod, 2002).

Retrieval induced forgetting in children

Much of the research investigating retrieval-induced forgetting has been done with adults. However, there have been a handful of studies that elicited retrieval induced forgetting in children (Aslan & Bäuml, 2010; Conroy & Salmon, 2005; Ford et al., 2004; Lechuga, Moreno, Pelegrina, Gomez-Ariza, & Bajo, 2006; Phenix & Price, 2012; Price & Phenix, 2015; Zellner & Bauml, 2005). Zellner and Bauml (2005), for example, examined 7- to10-year old children’s episodic memories and found that children produced RIF effects comparable to adults. Likewise Lechuga and colleagues (2006) examined older children (8- and 12-year-olds) and found that both age groups demonstrated levels of RIF similar to those of adults. However, only one study with children has discussed implications of RIF for forensic contexts (Phenix & Price, 2012). Akin to repeated abuse experiences, Phenix and Price (2012) examined whether repeated questioning about a repeated autobiographical experience that slightly differed each time could result in RIF. The researchers found that partial retrieval in an environment that facilitated interference (i.e., no integration) resulted in retrieval induced forgetting in children (7- and 10-year-olds) after long (2-h delay) and short (15-min) delays. The general conclusion of these studies was that school-aged children (7 years and older) appear to exhibit RIF effects comparable to those of adults in a variety of memory contexts, including autobiographical memory. Another aim of the present work was to continue to explore the contexts in which partial retrieval of a personally experienced event may result in retrieval induced forgetting in school-aged children.

THE PRESENT EXPERIMENTS

Children in the present experiments participated in the three traditional phases of the RIF paradigm: study phase (i.e., the play session), practice phase (i.e., category-cued retrieval task), and final test phase (i.e., cued-recall). During the study phase, children participated in a structured play session in which they witnessed a magician perform four science-based magic tricks. Children later practiced recalling some components of the tricks, and then participated in an exhaustive retrieval task about all elements of all tricks. In Experiment 1 we examined the impact of age and integration instructions on retrieval induced forgetting. In Experiment 2 we introduced a contiguity (i.e., time delay) manipulation between the practice and test phases.

EXPERIMENT 1

Participants

We recruited 117 children, 7–12 years (M_{age} = 9.40, SD = 1.39, age range: 6.75–11.75 years) from a summer science camp to participate in this study. Given the potentially distracting environment of a summer camp, we wanted to ensure that children attended to the task. Thus, participants who recalled less than 20% of items (fewer than 8/41 items) were removed from the data set. This resulted in the removal of two children's data, and a final sample size of 115 children. Parental consent as well as verbal assent was received for all participants. The study design was a 2 (Age: 6–9.99, 10+) × 2 (Instructions: integration, no integration) × 3 (Item type: Rp+, Rp−, Nrp) with Instructions and Age as between-subjects manipulations.

Procedure

Participants attended a five day summer camp. On the second day of the camp, children participated in a structured play session wherein a magician (i.e., a research assistant) performed four science-based magic tricks. In line with similar examinations of RIF in an autobiographical and developmental context (e.g., Phenix & Price, 2012), the items were presented as four distinct tricks within a single session. The order of the tricks was partially counterbalanced, with two random orders of the tricks presented. Each of the four magic tricks was presented in four distinct categories during the play session: (i) name of the trick; (ii) materials used during the trick; (iii) what happened during the trick; and, (iv) scientific secret behind the trick. Each of the four categories was verbally highlighted by the magician during her performance. The magic show lasted approximately 15 min. Because of the differing nature of the four magic tricks, each trick had a slightly different number of critical items (i.e., items that were pre-identified by the researchers as to-be-remembered details) to be recalled. Two of the tricks had a maximum of 11 critical items, while the other two contained 9 and 10 items. Across all the tricks, there were a total of 41 critical items presented to the children.

While the magician set up and between each of the live magic tricks, children were shown four videos of a man reading word lists that they were informed they would later be asked to remember. The word list recall was not part of the present study; however, some methodological details from that investigation are relevant for a complete understanding of the present work (see Figure 1). Half of the children received additional instructions from the man that directed the children to think of how the words can be grouped together or integrated before reading the word lists. The integration instructions provided to children were as follows: '*For each list of words you will hear, the words go together somehow. While you are listening to the word lists and trying to remember them, you should pay attention to how the words on each list go together.*' For children who were not in the integration instructions condition, no additional instructions were included. It is important to note that no instructions were provided to integrate the magic tricks for children in any condition.

The following day, participants engaged in a 5-min practice session during which research assistants presented children with two letter word-stems to cue recall. Immediately following the word stem recall for word lists, one critical detail from two of the above noted categories (i.e., trick name, materials, what happens, secret) for two of the four tricks were practiced using this procedure. That is, half of the magic tricks were subjected to partial retrieval practice. For example, a research assistant would ask, 'What material was used for the first trick?' and the children would be shown: P A __ __ __. Children were encouraged to complete the word stem by saying the critical item out loud (PAPER).

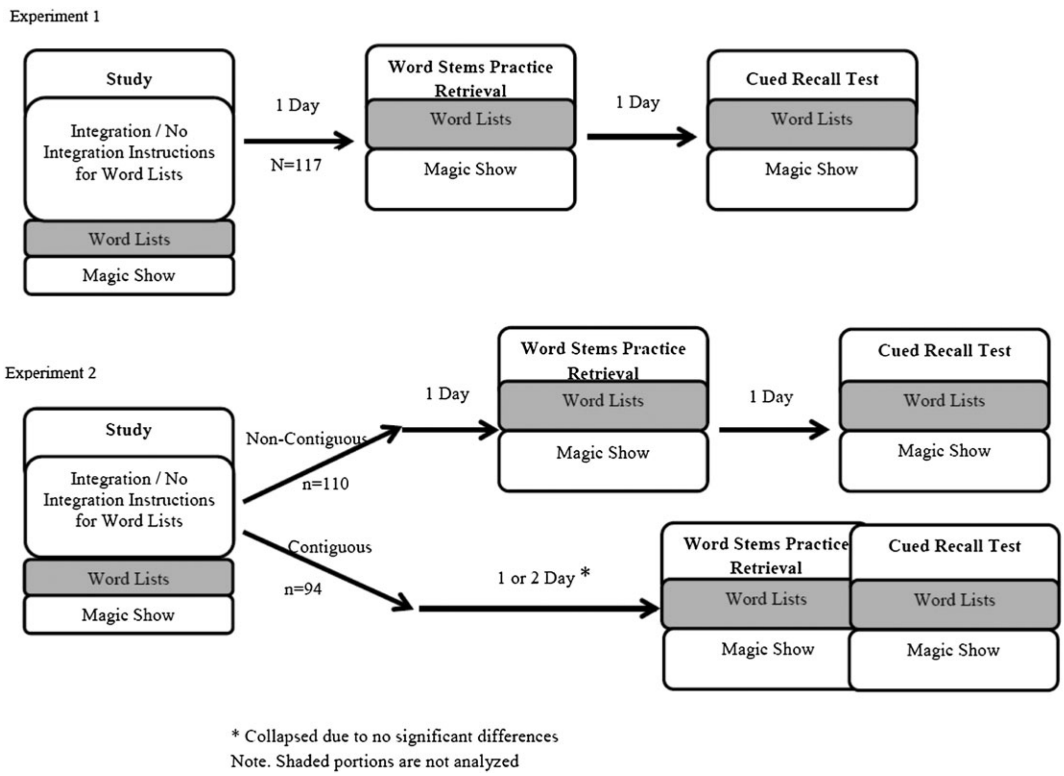

Figure 1. Experimental procedures

Table 1. Practiced counterbalancing sets

Magic trick	Practiced component				Magic trick total
	Name	Materials	What happened	Secret	
1	A,D	—	A	D	4
2	—	B,C	C	B	4
3	C	A	—	A,C	4
4	B	D	B,D	—	4
Category total	4	4	4	4	

Note.
A, B, C, D reflect the four different practice sets. For each Practice Set, children practiced components of two of the magic tricks. The remaining two tricks contained no practiced components (i.e., contained no Rp+ or Rp− items) and, therefore, were not included in the calculation of RIF. The two completed unpracticed tricks were included to allow us to counterbalance practiced tricks across conditions. For example, participants in Practice Set 'A' practiced part of the 'Name' and 'What Happened' components from trick 1 as well as part of the 'Materials' and 'Secret' components from trick 3. The items that were actually practiced items from the practiced components represent the Rp+, while other information in these components that were not practiced represents Rp−. The unpracticed components from tricks 1 and 3 represent Nrp items. The information recalled from tricks 2 and 4 were not included in the calculation of Nrp because all components from these tricks were completely unpracticed (i.e., no Rp+ or Rp− for these tricks).

If the child had difficultly, the research assistant sounded out the beginning of the word to assist the child in retrieving the appropriate word. Research assistants recorded each participant's response. Four word-stems were presented to participants during the practice session (two from each of the two partially practiced tricks), with each practiced item practiced one time. The remaining critical items were not practiced. The practiced critical items were counterbalanced across participants with four different sets of practiced/unpracticed items. Each set was designed such that participants practiced a combination of all the four magic trick components (i.e., name, materials, what happened, and secret) taken from the two practiced tricks. Across these four sets, each of the magic tricks as well as the different magic trick components was practiced four times. Table 1 provides a breakdown of the four practice sets: A, B, C, and D.

The next day, children received the recall test. During the final testing phase, children were provided with category cues for the word lists and asked to recall all the remaining words. Next, children were provided with category-cues for the magic tricks (i.e., What was the name of one of the magic tricks? What material was used for that trick?). Children were asked to verbally recall everything they could remember about each of the four categories for each trick. Tricks could be recalled in any order. Verbal, rather than written, recall was used to ensure that participants of all ages could carry out the task without restriction because of writing ability.

Item types compare with the standard RIF paradigm set (Anderson et al., 1994) in which Rp+ represents the practiced items, Rp− represents the non-practiced competitors, and Nrp represents the no retrieval practice items (i.e., baseline). The critical details used for analysis in the present study are exclusively from the two tricks from which a component was practiced and are comprised of: practiced category-practiced critical details (Rp+), practiced category-unpracticed critical details (Rp−), and unpracticed category-unpracticed critical details (Nrp). That is, although two tricks were completely unpracticed, these tricks were included only to allow us to counterbalance practiced tricks across conditions and thus are not considered in the analyses. Our intent was to explore the unpracticed (Nrp) critical items within each trick, rather than across tricks. Across all conditions, the maximum critical items to be recalled were 8 for Rp+, 13 for Rp−, and 20 for Nrp—or 41 critical items. Proportions were calculated for all analyses because of unequal maximum values per condition. A RIF score was computed by taking the difference between the proportions of Rp− and Nrp.

Coding

Participants were asked to recall the four categories for each of the four tricks, in any order they chose. Recall was then compared to the script of the play sessions and each detail from the script was dummy-coded as either recalled or not recalled. A coding guide was established with two research assistants, blind to participant condition, who randomly selected and coded approximately 30% of cases ($n = 31$). Disagreements were resolved through discussion. Inter-rater reliability was established and the ICC values (Cronbach's Alpha) for each participant's scores were high (i.e., there was low variation between raters; Bennell, Talbot, Wajswelner, Techovanich, & Kelly, 1998) and fell well above the acceptable ranged (ICC > .75 = excellent interrater agreement, Cicchetti & Sparrow, 1981). Following the establishment of inter-coder reliability, one coder coded the remainder of the data. Overall, most errors in recall were errors of omission; there were only seven participants that made commission errors. Taking into account each participant's practice condition, the raw data were then coded into appropriate Rp+, Rp−, and Nrp categories.

RESULTS

Cued recall responses were entered into a 2 (Age: 6–9.99, 10+) × 2 (Instructions: integration, no integration) × 2 (Item type: Rp−, Nrp) mixed model ANOVA. Descriptive data are presented in Table 2. There was an overall RIF effect, $F(1, 111) = 41.97$, $p < .001$, $\eta^2 = .27$, that was qualified by two interactions, one between Item Type and Instructions, $F(1, 111) = 33.30$, $p < .001$, $\eta^2 = .23$, and the other between Item Type and Age, $F(1, 111) = 6.88$, $p = .01$, $\eta^2 = .06$. To further explore the Item Type by Instruction interaction, pairwise comparisons were conducted to look at the RIF effect within each of the two instruction conditions. Consistent with expected effects of integration instructions on RIF, when integration instructions were given on an *unrelated preceding task*, there was no RIF effect, $F(1, 111) = 0.26$, $p = .61$, $\eta^2 = .002$, and when no integration instructions were provided there was a significant RIF effect, $F(1, 111) = 72.55$, $p < .001$, $\eta^2 = .40$. To explore the Item Type by Age effect, we used pairwise comparisons and found that both age groups displayed a RIF effect, though older children displayed a larger RIF effect, $F(1, 111) = 32.85$, $p < .001$, $\eta^2 = .23$, than younger children, $F(1, 111) = 10.06$, $p = 0.002$, $\eta^2 = .08$.

Table 2. Mean proportion recall rates by instructions and age for experiment 1

Item type	Overall	Integration instructions	
		No	Yes
Younger children	$N = 73$	$n = 45$	$n = 28$
Rp+	0.64 (0.29)	0.58 (0.29)	0.75 (0.27)
Rp−	0.45 (0.22)	0.38 (0.20)	0.56 (0.22)
Nrp	0.57 (0.23)	0.59 (0.23)	0.54 (0.24)
RIF	0.12 (0.29)*	0.22 (0.23)*	−0.03 (0.32)
Older children	$N = 42$	$n = 17$	$n = 25$
Rp+	0.82 (0.22)	0.78 (0.23)	0.85 (0.20)
Rp−	0.57 (0.24)	0.45 (0.22)	0.66 (0.22)
Nrp	0.77 (0.19)	0.84 (0.16)	0.72 (0.20)
RIF	0.19 (0.28)*	0.39 (0.27)*	0.06 (0.19)
Total experiment 1	$N = 115$	$n = 62$	$n = 53$
Rp+	0.71 (0.28)	0.63 (0.29)	0.80 (0.25)
Rp−	0.49 (0.24)	0.40 (0.21)	0.61 (0.22)
Nrp	0.64 (0.24)	0.66 (0.24)	0.62 (0.24)
RIF	0.15 (0.29)*	0.27 (0.25)*	0.02 (0.27)

Note.
RIF = a difference score (NRP minus RP−).
*Denotes statistical significance at $p < .05$. Values in parentheses represent standard deviations. Note: Effects of integration instructions on magic trick recall were unanticipated and thus, balancing of participant numbers per condition was originally performed on word list conditions, rather than magic trick conditions.

EXPERIMENT 1 DISCUSSION

In Experiment 1, we found evidence of retrieval-induced forgetting in event memories in school-aged children—but especially in older children. More interestingly, we also found that providing children with basic integration instructions during an unrelated task (i.e., word lists), had an attenuating effect on the level of retrieval-induced forgetting for the magic show. To the best of our knowledge, this 'spill-over' effect of the integration instructions has not been observed in any other developmental research. As such, we wanted to replicate the findings of Experiment 1 and determine the robustness of the 'spill-over' effect. If the effect is only short term, the implications of Experiment 1 are more limited. As such, we also examined the impact that delay has between the retrieval practice and test phases. Prior research with children has found inconsistent effects of delay (e.g., Phenix & Price, 2012), and this is likely to be an important factor in an applied context. With a delay introduced between practice and test, we anticipated that any effect of RIF may be reduced, or perhaps even absent (MacLeod & Macrae, 2001).

EXPERIMENT 2

Participants

We recruited 220 children, 7–15 years ($M_{age} = 10.20$, $SD = 2.99$, age range: 6.83–15.75 years) from a summer science camp. Again, participants who recalled less than 20% of items were removed to ensure participants were attending to the task—reducing the sample size to 204 children. Parental consent as well as verbal assent was received for all participants. The study design was a 2 (Age: 6–9.99, 10+) × 2 (Contiguity: contiguous, non-contiguous) × 2 (Instructions: integration, no integration) × 3 (Item type: Rp+, Rp−, Nrp) with Instructions, Age, and Contiguity as between-subjects manipulations.

Procedure

The procedure for Experiment 2 was the same as Experiment 1 but with an added variable of Contiguity— a manipulation of how proximate the retrieval practice phase was to the test phase. Children in the contiguous condition were asked to answer the practice questions (i.e., practice phase) and the cued-recall (i.e., test phase) in the same session, either one or two days following the study phase.[1] Children in the non-contiguous condition were asked to answer practice questions and the cued-recall questions in separate sessions, one day apart.

Coding

The coding procedure established in Experiment 1 was used. Two research assistants randomly selected and coded 30% of the data ($n = 68$). Inter-rater reliability scores (ICC) were well above the acceptable range (ICC > .75 = excellent interrater agreement, Cicchetti & Sparrow, 1981).

RESULTS

Cued recall responses were entered into a 2 (Age: 6–9.99, 10+) × 2 (Instructions: integration, no integration) × 2 (Contiguity: contiguous, non-contiguous) × 2 (Item type: Rp−, Nrp) mixed model ANOVA. Descriptive data are presented in Tables 3 and 4. There was an overall RIF effect, $F(1, 196) = 14.06$, $p < .001$, $\eta^2 = .07$, that was qualified by two interactions: one between Item Type and Instructions, $F(1, 196) = 8.14$, $p = .005$, $\eta^2 = .04$, and the other between Item Type and Contiguity, $F(1, 196) = 6.50$, $p = .01$, $\eta^2 = .03$. There was no interaction between Item Type and Age, $F(1, 196) = 2.36$, $p = .13$, $\eta^2 = .01$, nor were there any significant three-way interactions. Similar to Experiment 1, when integration instructions were given on an unrelated preceding task, there was no RIF effect, $F(1, 181) = 0.34$, $p = .56$, $\eta^2 = .002$, and when no integration instructions were provided there was a significant RIF effect, $F(1, 181) = 20.03$, $p < .001$, $\eta^2 = .10$.

To explore the Item Type by Contiguity effect, we used pairwise comparisons and found that when there was contiguity between retrieval practice test and cued-recall there was a significant RIF effect, $F(1, 181) = 16.20$, $p < .001$, $\eta^2 = .08$, but the non-contiguity condition did not produce an RIF effect, $F(1, 181) = 0.85$, $p = .31$, $\eta^2 = .006$.

Finally, given that the interaction between Instructions and RIF was unexpected in Experiment 1, we sought to explore if we could directly replicate the effect of RIF in the non-contiguous condition in Experiment 2. Thus, we

[1] Note that there was no significant difference between the 1 and 2 day conditions, $t(111) = 1.40$, $p = .16$, so they were collapsed.

Table 3. Mean proportion recall rates by instructions and age for experiment 2

Item type	Overall	Integration instructions	
		No	Yes
Younger children	$N = 97$	$n = 37$	$n = 60$
Rp+	0.64 (0.26)	0.63 (0.21)	0.65 (0.28)
Rp−	0.54 (0.23)	0.50 (0.26)	0.56 (0.21)
Nrp	0.57 (0.25)	0.61 (0.23)	0.54 (0.26)
RIF	0.03 (0.29)	0.11 (0.29)	−0.01 (0.28)
Older children	$N = 106$	$n = 68$	$n = 39$
Rp+	0.73 (0.24)	0.71(0.24)	0.76 (0.25)
Rp−	0.55 (0.23)	0.54 (0.23)	0.58 (0.23)
Nrp	0.67 (0.26)	0.69 (0.27)	0.63 (0.24)
RIF	0.12 (0.26)	0.16 (0.27)	0.06 (0.25)
Total Experiment 2	$N = 204$	$n = 105$	$n = 99$
Rp+	0.69 (0.25)	0.68 (0.23)	0.70 (0.27)
Rp−	0.54 (0.23)	0.53 (0.24)	0.56 (0.22)
Nrp	0.62 (0.26)	0.66 (0.26)	0.58 (0.26)
RIF	0.08 (0.28)*	0.14 (0.27)*	0.02 (0.27)

Note.
RIF = a difference score (NRP minus RP−).
*Denotes statistical significance at $p < .05$. Values in parentheses represent standard deviations. Note: Effects of integration instructions on magic trick recall was unanticipated and thus, balancing of participant numbers per condition was originally performed on word list conditions, rather than magic trick conditions.

Table 4. Mean proportion recall rates by contiguity and age for experiment 2

Item type	Overall	Contiguity	
		Contiguous	Non-contiguous
Younger children	$N = 97$	$n = 54$	$n = 43$
Rp+	0.64 (0.26)	0.68 (0.29)	0.60 (0.20)
Rp−	0.54 (0.23)	0.53 (0.24)	0.55 (0.22)
Nrp	0.57 (0.25)	0.58 (0.26)	0.55 (0.25)
RIF	0.03 (0.29)	0.05 (0.29)	0.01 (0.29)
Older children	$N = 107$	$n = 56$	$n = 51$
Rp+	0.73 (0.25)	0.81 (0.20)	0.64 (0.26)
Rp−	0.55 (0.23)	0.57 (0.24)	0.53 (0.22)
Nrp	0.67 (0.26)	0.76 (0.21)	0.58 (0.28)
RIF	0.12 (0.26)	0.18 (0.23)	0.05 (0.28)
Total experiment 2	$N = 204$	$n = 110$	$n = 94$
Rp+	0.69 (0.25)	0.74 (0.26)	0.62 (0.23)
Rp−	0.54 (0.23)	0.55 (0.24)	0.54 (0.22)
Nrp	0.62 (0.26)	0.67 (0.25)	0.57 (0.26)
RIF	0.08 (0.28)*	0.12 (0.26)*	0.03 (0.29)

Note.
RIF = a difference score (NRP minus RP−).
*Denotes statistical significance at $p < .05$. Values in parentheses represent standard deviations.

examined only the non-contiguous condition from Experiment 2 with a 2 (Age: 6–9.99, 10+) × 2 (Instructions: integration, no integration) × 2 (Item type: Rp−, Nrp) mixed model ANOVA. There was no overall RIF effect, $F(1, 90) = 0.63$, $p = .43$, $\eta^2 = .007$, and no significant interaction between RIF and Age, $F(1, 90) = 0.31$, $p = .58$, $\eta^2 = .003$. There was, however, a trend towards an interaction between RIF and Instruction, $F(1, 90) = 3.69$, $p = .06$, $\eta^2 = .04$. Although the latter interaction did not reach statistical significance, as it did in Experiment 1, the pattern of responses was highly similar and the interaction may not have been as powerful in Experiment 2 because of the larger age range (Exp. 1: 6.75–11.75 years, $M_{age} = 9.40$, $SD = 1.39$; Exp. 2: 6.83–15.75 years, $M_{age} = 10.20$, $SD = 2.99$) and smaller number of participants in the analysis (Exp. 1, $n = 115$; Exp. 2, $n = 94$).

EXPERIMENT 2 DISCUSSION

In Experiment 2, we replicated the overall retrieval-induced forgetting effects seen in Experiment 1. In addition, we partially replicated support for a 'spill-over' effect of integration instructions for an unrelated task. Integration instructions only impacted RIF levels when the test phase (i.e., cued recall) immediately followed the practice phase (i.e., word stem). There was also some evidence (non-significant) of RIF in the non-contiguous condition for Experiment 2. These results speak to the persistent impact of integration instructions across differing study contexts. Also, this study demonstrated that RIF for event memory was dependent upon the temporal contiguity between retrieval-practice and test phases. Similar to previous research (Phenix & Price, 2012; Price & Phenix, 2015), a closer proximity between retrieval-practice and test phases increased the likelihood of observing RIF. However, this pattern of retrieval-induced forgetting is not consistent in the literature. Some researchers have observed retrieval-induced forgetting effects in adults even after a large time delay between the practice and test phases (e.g., 1 week; Garcia-Bajos, Migueles, & Anderson, 2009), while others have found RIF to only exist when there are short delays between the practice and test phases (e.g., less than 24 h; MacLeod & Macrae, 2001). It remains unclear why there is variability in the stability of RIF. Nonetheless, these results add to this discussion by providing evidence that susceptibility to RIF for event memory may attenuate with increased time between partial and final retrieval.

GENERAL DISCUSSION

We sought to explore how partial retrieval of a complex event could impact subsequent retrieval of that event in school-aged children. The underlying motivation was to explore how cued-questioning for child witnesses would impact their later complete recall attempt of an experienced event. Children typically report the most accurate information in response to open-ended questions (e.g., tell me what happened). The problem, however, is that young children frequently report less information than older children and adults when responding to these types of desirable prompts (e.g., Cederborg, Orbach, Sternberg, & Lamb, 2000; Fivush, 1997; Lamb, Sternberg & Esplin, 2000). Therefore, to elicit more detail from child witnesses, it is commonly recommended that investigative interviewers use open-ended prompts that focus the witness on a specific aspect of their described experience (Lamb et al., 2007; Poole & Lindsay, 1998). In line with these investigative interviewing methods (though there was no initial description provided by children from which to draw the cued questions), we asked children cued-recall questions regarding some—but not all—aspects of an interactive experience (i.e., a magic show). The results indicated that partial cued-recall of the experience produced retrieval-induced forgetting in school-aged children—and this was especially true for the oldest children in the sample. That is, the details of the experienced event that were related to the practiced details, but were unpracticed, were less likely to be later recalled than unpracticed details.

These data also provide some insight into effortful remembering. Children were only instructed to remember the word lists, not the magic tricks and, thus, we assume that they expended comparatively greater effort to remember the word lists. Despite being only instructed to remember the word lists, evidence of retrieval-induced forgetting was found for both the magic trick and word list (Price & Phenix, 2015) components of the experience. These results indicate that retrieval-induced forgetting is observed regardless of the whether participants are directed to remember the events. It may be important to note that the magic trick component of the experience may have been quite salient to the children and thus produced a memory trace equivalent to or stronger than effortful remembering of word lists.

These RIF results are interesting considering the nature of the retrieved event. Memory for an interactive event, such as a live magic show, has several inherent differences from traditional word lists. Although the word lists were grouped by themes or categories, the magic tricks presented a much more loosely related, but cohesive group of details to remember than the word lists. Event memory is thought to be processed in a more organized way than other types of information because of previous knowledge schemata (Reiser, Black & Abelson, 1985). These integrated schemas have been found to be highly resistant to inhibitory processes (Anderson & McCulloch, 1999; Migueles & Garcia-Bajos, 2007). For example, Migueles and Garcia-Bajos (2007) analyzed retrieval-induced forgetting in eyewitness memory for an event containing organized actions (a robbery) and found evidence of retrieval-induced forgetting for offender characteristics, but not for event actions. The reason for this, they argued, is that prior knowledge about the event (a robbery) helped to integrate the information about actions during exposure. Like the robbery video used in Migueles and Garcia-Bajos' (2007) study, the magic show can be classified as an event containing organized actions where we could expect to see more organized encoding and storage of the event (relative to the word lists). Despite this, we still found evidence of retrieval-induced forgetting within the magic tricks—that is, recalling components of a trick negatively impacted recall for other components of the same trick. These results suggest that, even for a cohesive event in which a child is an active member, retrieval-induced forgetting can occur.

This observation may be explained in at least two ways. First, it is possible that the children processed the magic show as a series of separate, contextually-related events—four distinct magic tricks, each with four separate components separated in time. If this was the case, the actions of the events were likely encoded in a less integrative manner and were thus more susceptible to RIF. On the other hand, children may have processed the magic show (or tricks within the show) as one event, but lacked the schemata or previous knowledge structures necessary to spontaneously organize and integrate the actions of the event. A relatively robust finding in the developmental memory literature is that a child's ability to encode and retrieve semantic representations of an event improves with age (e.g., Brainerd & Reyna, 2002, 2005). Thus, children may not have the base semantic structure to naturally integrate these experiences as a cohesive unit—unless directed to use such a processing style via integration instructions.

Robustness of integration instructions

A particularly fascinating finding with the present data pertains to the robustness of integration instructions. As previously discussed, participants were initially presented with integration instructions for an unrelated memory task (remembering word lists). No such instructions were provided for remembering the magic tricks. Despite this, the integration instructions for the word list component appeared to have a residual or spill-over effect onto the magic trick component. That is, children were less likely to exhibit retrieval-induced forgetting when they received integration instructions during a completely unrelated initial task.

The present findings suggest that integration instructions not only have a dampening effect on retrieval induced forgetting (i.e., a boundary effect; Anderson & McCulloch, 1999), but that integration instructions may also influence the style in which children process all aspects of an experience, whether a person is passively (hearing word lists) or actively (interactive magic show) part of the experience. Cognitive style is a person's preferred method of gathering, processing and evaluating information that impacts what information is of value in the environment, how a person organizes and interprets this information, and how the information is integrated (Hayes & Allinson, 1998). Some researchers have argued that processing styles are malleable and can change either consciously or unconsciously (Goodmon & Anderson, 2011; Hayes & Allinson, 1998) in response to instructions (Schmeck, 1981). Although more direct research on the spill-over effect is needed, we speculate that the integration instructions given to the children during the word-list task may have placed them in the mind-set of seeing the individual parts of the immediate subsequent experience as part of the whole experience.

From a theoretical perspective, integration is thought to eliminate underlying competition between related, practiced and non-practiced exemplars (Anderson & McCulloch, 1999; Goodmon & Anderson, 2011) and the critical details are no longer seen in isolation, but as part of a whole. However, we lack a complete understanding of the mechanism that guides the relationship between integration and forgetting (Carroll et al., 2007). This is especially true of the relationship between integration and children's forgetting. The pattern of responding observed with the introduction of integration instructions speaks to this issue. We anticipated that the introduction of integrative thinking would increase the Rp− recall but have minimal impact on the level of baseline recall (Nrp) recall (e.g., Smith & Hunt, 2000). This pattern would suggest that integration plays a role in mitigating the suppression of highly related items in memory. However, for both experiments, the integration instructions resulted in a non-significant, but numerical increase in recall for those belonging to, or related to, the practiced category, as well as a potential trend towards a drop in baseline recall. This pattern is difficult to reconcile with the integration interpretation for the eliminated RIF effects that have been previously reported. For children, retrieval-induced forgetting and, by extension integration as a boundary condition for retrieval-induced forgetting, may not reflect an inhibitory or suppression mechanism (Anderson, 2003; Ford et al., 2004). The present data support the notion of integration as a boundary condition for children's forgetting; however, the (non-significant) drop in baseline recall may indicate that integration acts on a mechanism other than suppression.

It is possible that introducing an integrative thinking style increases memory load and, ultimately how much the children can recall. For instance, when asking children to consider how the information 'goes together,' more mental energy may be used to integrate information from a single category—increasing recall of the Rp+ and Rp− items. This improved recall may come at a cost when recalling unrelated, unpracticed (baseline) items. More research is needed to further explore the mechanism that guides the relationship between integration and forgetting in children.

Applied context

From a pragmatic standpoint, this study provides further evidence that child witnesses or victims are susceptible to later memory failure because of initial partial questioning. This means that incomplete initial retrieval attempts (e.g., cued-recall type questioning), may negatively impact how well a child can subsequently recall other information about that event. The negative impact of initial, partial-questioning clearly disappeared with integration instructions, or the consideration of how an experience 'goes together,' prior to initial exposure. Although theoretically fascinating, the robust finding of integration instructions does not provide much of an advantage from a forensic interviewing perspective. A child victim or witness would not have the opportunity to think or reflect on an upcoming event—that is, we are not able to provide integration instructions before a child witnesses a crime. In an applied setting, the first opportunity to try to shield a child witness from retrieval-induced forgetting is immediately before their first recount of an event. These results raise an interesting practical question: would we find a benefit of integration instructions if they were provided immediately before the first recall (practice phase)?

These experiments, along with many others (e.g., Anderson & McCulloch, 1999; Phenix & Price, 2012), demonstrate the effects of presenting integration instructions at the time of encoding on retrieval-induced forgetting. It is likely that integration instructions are most advantageous at the time of encoding an experience. It is at this point that the information can be observed, organized, and stored in a coherent and meaningful way. Nevertheless, memory retrieval is a complex process that researchers can exhibit some influence over (Spear, 1974). Future research should examine whether introducing integrative-style processing at the initial stage of retrieval impacts forgetting in children. From an applied perspective, integrative processing may be introduced by asking a child to discuss or think about the entire event prior to any specific recall. Recent recommendations for interviewing children about repeated instances of abuse, for example, have included eliciting recall of general event details prior to eliciting recall of an instance of the series, with the presumption that this general recall will facilitate recall of instance-level details (e.g., Brubacher et al., 2014). In a review of 105 forensic interviews of children who were victims of repeated sexual abuse, Brubacher, Malloy, Lamb and Roberts (2013) reported that investigative interviewers use this technique in practice and often allow children to recall general details about the events before prompting them for specific episodic information about an event. The present findings, and the future investigation they encourage, may provide some further theoretical motivation for a recommendation to elicit integrated recall prior to targeting specific details.

CONCLUSION

We found clear evidence of retrieval-induced forgetting in children's reports of event memory. These effects were dependent upon whether children were directed to think in an integrative manner about an unrelated task. These results indicate there may be potential costs that stem from repeated, cued-question interviewing strategies that ask about partial parts of an experience. Further, the robust impact of integration instructions provides evidence that associatively thinking about an experience may help protect children against retrieval-induced forgetting.

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