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Binding an Event to Its Source at Encoding Improves Children's Source Monitoring

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Children learn information from a variety of sources and often remember the content but forget the source. Whereas the majority of research has focused on retrieval mechanisms for such difficulties, the present investigation examines whether the way in which sources are *encoded* influences future source monitoring. In Study 1, 86 children aged 3 to 8 years participated in 2 photography sessions on different days. Children were randomly assigned to either the *Difference* condition (they were asked to pay attention to differences between the 2 events), the *Memory control* condition (asked to pay attention with no reference to differences), or the *No-Instruction control* (no special instructions were given). One week later, during a structured interview about the photography session, the 3- to 4-year-olds in the No-Instruction condition were less accurate and responded more often with 'do not know' than the 7- to 8-year-olds. However, the older children in the Difference condition made *more* source confusions than the younger children suggesting improved memory for content but not source. In Study 2, the Difference condition was replaced by a *Difference-Tag* condition where details were pointed out along with their source (i.e., tagging source to content). Ninety-four children aged 3 to 8 years participated. Children in the Difference-Tag condition made fewer source-monitoring errors than children in the Control condition. The results of these 2 studies together suggest that binding processes at encoding can lead to better source discrimination of experienced events at retrieval and may underlie the rapid development of source monitoring in this age range.

Keywords: binding, encoding, event memory, source monitoring

Access to information is relatively easy in contemporary society because of the multitude of available information sources. Instead of visiting a library to obtain specialist knowledge (e.g., a guide to building a shed), many people use an Internet search engine at home. Perhaps some people use both the Internet and books and integrate the knowledge before embarking on a large deck project. But what if some of the information was found to be incorrect? Without identifying the source of information (book or Internet) at recall, further errors might be made because one cannot 'edit out' other information from the inaccurate source. Identifying the source of information is known as 'source monitoring' (Johnson, Hashtroudi, & Lindsay, 1993) and impairments have consequences not just on our knowledge, but also our autobiographical memories, friendships, and many areas of our daily lives. Preschoolers (ages 3–6) show impressive gains in source-monitoring skills, most likely because of the maturation of frontal lobes during this time (see Raj & Bell, 2010, for a review). As source monitoring requires automatic or intentional reflection on the sources of information when memories are retrieved (i.e., relatively advanced cognition), full proficiency is not developed until late childhood. It is not clear, however, what exact mechanisms develop during this period. Children might not encode source information, they might forget source information faster than other information, or they might not be able to retrieve source information.

Most research with this age group has focused on retrieval mechanisms; for example, examining the effect of basic source monitoring training prior to retrieval on source accuracy (O'Neill & Gopnik, 1991; Poole & Lindsay, 2002; Thierry, Lamb, Pipe, & Spence, 2010; Thierry & Spence, 2002). We argue that the way in which information and their sources are encoded can also have large consequences on future source monitoring at retrieval. We therefore focused our investigation on the encoding phase by examining how different foci at encoding affect later source monitoring.

The Development of Source Monitoring

It is well-established that people, of any age, often blend information from multiple sources together (see Roberts, 2002, for a review). For example, people can blend memories of TV and real-life events (Roberts & Blades, 1999; Thierry & Spence, 2002), live events and stories (Thierry, 2009), film and narrative about film (e.g., Ackil & Zaragoza, 1995; Thierry & Pipe, 2009), different instances of a similar event (Brubacher, Glisic, Roberts, & Powell, 2011; Connolly & Lindsay, 2001; Powell, Roberts, Ceci, & Hembrooke, 1999), or real-life and suggestions about the real-life event (Welch-Ross, 1999).

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The ability to monitor where we obtained information from has been found to improve during the preschool years. For example, in developmental studies, 3- to 4-year-olds routinely evidence higher levels of source confusion than older children and adults (e.g., Ackil & Zaragoza, 1995; Roberts & Blades, 1999) and even display source amnesia (forgetting the sources; Drummey & Newcombe, 2002). In one study, Roberts and Blades (1999) found that 4-year-olds were more likely than 6-year-olds and adults to mistakenly think that events they had watched on video had actually happened. Ackil and Zaragoza (1995) demonstrated that source monitoring skills continue to develop after 4 years of age. In their study, 5- to 11-year-olds and adults watched a video, and then listened to an inaccurate summary of the film. Although all age groups mistakenly claimed that some suggested items occurred in the video, there was a developmental decrease in source errors.

Understanding why children can progress from such basic source-monitoring skills to adult competence is informed by Johnson's Multiple-Entry Modular Memory model of memory (Johnson et al., 1993; MEM). The MEM model outlines two sets of processes: a perceptual set and a reflective set. According to the model, source is attributed at retrieval as the result of these processes. Memories containing high levels of perceptual detail can lead us to assume that an event was observed rather than imagined (because we assume that such detail would not be present in a memory of an imagined event). Sometimes these decisions are made effortlessly and without awareness. At other times, we need to be more intentionally reflective to attribute source (e.g., *I couldn't have seen it because I was not there*).

Although these attributions are thought to take place at retrieval, what is retrieved is dependent, at least to some extent, on what is encoded. Lindsay outlined some possible explanations for children's difficulty distinguishing between similar sources. In one experiment (Lindsay, Johnson, & Kwon, 1991; Study 1), 4-year-olds were more confused than adults when distinguishing which of two actors of the same gender said particular words. Lindsay argued that children's difficulty with distinguishing the two speakers may have been because unique information about the speakers was not accessible at test or that children did not even attend to the relevant (unique) aspects of the speakers. Friedman and Lyon (2005) provided two class demonstrations to children aged 4 to 13 years, and three months later asked children to recall the time of the events. Although the 6-year-olds were able to correctly recall the order of the two events (i.e., two sources), there were developmental increases in accuracy for other temporal properties such as estimating how long ago the events were. Temporal information can be reconstructed, for example, knowing that I was at a conference in 2004 because I remember I was pregnant and the child was born a few weeks later. Clearly, such reconstruction is only possible if relevant source information is encoded. As pointed out by Friedman and Lyon, it was not until middle childhood that temporally relevant episodic information was available to aid in identifying the temporal source of events.

Further evidence for the importance of encoding is provided by a set of studies by Newcombe and colleagues (Kovacs & Newcombe, 2006; Lloyd, Doydum, & Newcombe, 2009; Sluzenski, Newcombe, & Kovacs, 2006). In these studies, children show few age differences when identifying objects or contextual information (location, scenes) they have seen before, but children aged 3 to 4 show impairments relative to older children when recognizing item and context information concurrently (e.g., Did you see the pig in this square?). Newcombe and colleagues argue that these results reflect the difficulty that young children have when *binding* different aspects of experiences together, in this case, the pig and its location. According to the MEM model, binding is important in source monitoring because the perceptual (e.g., Gestalt processes) and reflective (e.g., noting relations between stimuli) processes act on information to bind content and its context together.

Impairments in binding in young children also make sense in the context of other cognitive developments. Between 3 to 6 years of age, substantial progress is made in tasks involving working memory and executive processes (Zelazo & Muller, 2002). Both the *episodic buffer* (Baddeley, 2000), which binds features from short and long term memory, and the MEM framework suppose that executive processes direct attention and resources to particular features—those most characteristic of the to-be-remembered stimuli (Johnson et al., 1993; Ruffman, Rustin, Garnham, & Parkin, 2001). Some features are processed at the expense of others, so children who are still strengthening their working memory and executive systems may not be able to adequately direct their attention to and encode those features most relevant for later source attribution.

Interestingly, source monitoring, executive functioning (e.g., working memory), and binding processes have been localized in similar brain regions, and development of these neural structures coincides with known developmental patterns of cognitive functioning. Much of the evidence comes from studies of aging because older adults tend to show lower accuracy when monitoring sources than do younger adults (i.e., a very similar relationship to comparisons between young children and adults). For example, Glisky, Rubin, and Davidson (2001) showed that older adults were less accurate when monitoring sources than younger adults *only* when the seniors had below average frontal function. In investigations of episodic memory with adults, activation of the medial temporal lobe (including the hippocampal regions and the amygdala) is correlated with item and source memory, and the hippocampus is particularly activated when correct source judgments are made (Davachi, Mitchell, & Wagner, 2003). Lesion (e.g., Cabeza, 2006), ERP (e.g., Wilding & Rugg, 1996), and fMRI studies (e.g., Nolde, Johnson, & D'Esposito, 1998) provide converging evidence. Parallel neural investigations with children are sparse and usually limited to children aged 6-years and above, possibly because of behavioral limitations (e.g., the need to remain still during a fMRI). The evidence to date, however, has revealed a similar neurological profile. For example, Ghetti, DeMaster, Yonelinas, and Bunge (2010), in their study of middle childhood (aged 6 to 10 years), found that hippocampal and parahippocampal regions of the medial temporal lobe were associated with the retrieval of source-specifying information. It is evident that researchers have provided important neurological evidence regarding the retrieval of information, yet it is important to have similar data at the time of encoding to have a fuller picture of neural and cognitive processes.

In sum, encoding processes are likely to play a major part in the development of source monitoring because what is encoded, bound together, and retrieved determines whether children can make accurate source attributions. The type and quality of encoding processes, however, might be constrained by the developing cognitive skills such as working memory and executive function. In the present investigation, we focus on experimental manipulations of encoding instructions and its subsequent effects on source monitoring.

Types of Encoding Processes

We were interested in testing two specific types of encoding foci: distinctiveness and binding. First, because it is easier to distinguish between sources that are distinct from each other (vs. those that are similar: Kovacs & Newcombe, 2006; Lindsay et al., 1991; Roberts & Blades, 1999; Thierry et al., 2010), focusing on the *differences* between sources should improve source monitoring. Sources can be easily attributed if one retrieves information that is unique to one source. It is possible that, because children lack complete knowledge about what features are most relevant to source attribution, directing their attention to distinctive features aids in both the encoding and subsequent retrieval of relevant source information.

Awareness of the differences between events provides an opportunity to direct attention toward encoding these relevant features rather than other features that will be less helpful in source attributions. Children tend to be quite good at noting differences when they are deviations from the norm. For example, after repeated experiences of similar events children can notice deviations from what typically occurs and accurately attribute usual and deviant details to their sources (e.g., Farrar & Boyer-Pennington, 1999; Farrar & Goodman, 1992). However, other differences between events may not be so obvious, such as when there is constant variation across individual repetitions of an event. In a recent study, children participated in classroom activities on four different days (Brubacher et al., 2011). Some of the props changed each day, for example, children read a story but it was a different story each day. Children were later confused about which story went with which day, but they were aware that the story was different each time and could often spontaneously describe the different stories.

The second type of encoding we examined focused on *binding* features of the event together. There are many studies showing that children have impressive memories of the content of different sources (e.g., Brubacher et al., 2011; Brubacher, Roberts, & Powell, 2012; Powell et al., 1999), but tagging the content to the correct source is very difficult for children (Pathman, Samson, Dugas, Cabeza, & Bauer, 2011). We reasoned that explicitly making links between content and source at the encoding stage would increase the chances of accurate source attribution later. Importantly, strengthening the links between content and source may be a way that children can automatically make source decisions. Automatic source decisions reduce dependence on more advanced reflective processes that might be beyond their development (given immature hippocampal regions [e.g., Ghetti et al., 2010]).

In a study that involved binding content to its source (Lloyd et al., 2009), even children as young as 4 years old were able to attribute source as accurately as 6 year-olds when the memory components of the task were minor. Specifically, Lloyd et al. found that children could accurately identify which objects and which background scenes co-occurred at encoding, but the 4-year-olds showed impairments after a delay. Lloyd et al. argued that these younger children were unable to retrieve the bound material that would lead to correct source attributions. Therefore, in the current study, we reasoned that if we strengthened the binding of content and source by explicitly drawing children's attention to the differences in each source (Study 1) or explicitly linking these differences to a particular source (Study 2), that they would later be more likely to correctly attribute source because the bound material would survive a delay.

In Lloyd et al.'s (2009) study, as in many other studies on source monitoring (e.g., Evans & Roberts, 2009; Thierry & Spence, 2002), the sources to be distinguished are directly observable (e.g., background scenes vs. locations on a grid, Lloyd et al.) and often explicitly labeled (e.g., interviewer vs. computer, Evans & Roberts, 2009; TV vs. live events, Thierry & Spence, 2002). In the current study, we were more interested in children's source monitoring for naturalistic events when the source is more *indirect*, though no less important. Children participated in two dress-up sessions and were later asked to identify which features corresponded to each dress-up session. Thus, the sources were the two different sessions meaning that the source has to be extrapolated using contextual information such as temporal and semantic properties (e.g., one source was 'the Time I dressed up as a doctor').

If children were able to attribute information to these unobservable sources it provides a strong test of the encoding processes. Specifically, we investigated rehearsal and repetition of unobservable sources. If children do benefit from the encoding manipulations, it provides strong evidence that encoding is related to the accuracy of future source monitoring of events and partly underlies children's developmental progress in source monitoring. In sum, we expected that explicit encoding instructions (presumably enhancing encoding) would lead to more accurate source monitoring for two events. In Study 1, we tested the effects of explicit instructions for the encoding of differences; in Study 2, we attempted to enhance the processing of material with the binding of its source through instructions that tagged the item to its source.

Study 1

Method

Participants. Children aged 3 to 4 years ($N = 45$; $M = 59.22$ months, $SD = 7.88$) and 6 to 8 years ($N = 41$; $M = 83.44$ months, $SD = 7.90$) participated. Children were recruited from local daycares and schools in a midsized North American city. The ethnic and socioeconomic makeup of the participants reflected the white, European, and Asian lower- to middle-class neighborhoods from which they were recruited.

Procedure.

The events. Each child dressed up as a pirate two times in small groups of 2 to 4 during two photography sessions held on different days, two days apart. In one photography session, the female confederate (the research assistant; RA) dressed up as a cowgirl; in the other, a medical doctor. A sample script is presented in Appendix A.

There were 21 target details that varied in each event (e.g., a different badge each time; see Appendix B for the full list of target details). The events followed the same preplanned order where the child and photographer helped each other dress up in costumes, and then photographs were taken. Each event lasted about 15 min and the presentation of events was counterbalanced between participants.

Children were randomly assigned to one of three encoding conditions. In the *Difference condition*, children were told that they would participate in two photography sessions and were *explicitly instructed to pay attention to any differences* between these two events. The RA said

> I want you to watch what happens really carefully today. I'm going to take your photograph again on a different day. And some things will be different. So watch really carefully today so you will know what's different next time. OK?

Throughout the photography session, she drew attention to each target item by saying, for example, "this time you are [wearing a flag badge]. Watch very carefully because next time it will be a different [badge]."

In the *Memory Control* condition, children were informed that they would participate in two events and instructed to pay attention, but with *no reference to event differences*. The RA said, "I want you to watch what happens really carefully today. I'm going to take your photograph again on a different day. So watch really carefully today. OK?" Throughout the session she drew attention to each item by saying, for example, "Now I am putting on your [flag badge], watch very carefully." Children in the *No-Instruction Control* condition received no special instructions and were not explicitly told that there were two photography sessions. Throughout the session each item was mentioned but children were not explicitly instructed to pay attention to it, for example, "Here's your badge. It's a [flag] badge because it has [a picture of a flag] on it. I'm going to put the [flag] badge on you."

The interview. A week after the first event (range 7 to 8 days), children were either interviewed about the first or second session that they had participated in (counterbalanced across age and condition groups) by a new RA. The session began by telling children the 'ground rules' and giving them practice with each rule including: telling the interviewer they made a mistake, that they could say 'I do not know,' and that they should only talk about things that really happened. During a brief rapport-building period (3 to 4 min) children were encouraged to talk about a recent event other than the photography sessions (e.g., a recent birthday or school trip). The interviewer then directed their attention to the photography events by saying

> I understand that you met a photographer last week and did lots of things with the photographer. I wasn't there when you met the photographer but I'd really like to know what happened. Tell me everything you remember from the very beginning to the very end.

Of particular interest for the present study, following recall of one of the photography sessions, 21 cued-recall questions were asked about the specific session under discussion (e.g., "What color was your badge, the day she dressed up as a cowgirl/doctor?", see Appendix C), that is, making the source explicit to encourage children to think about a particular event.

Responses to the cued-recall questions were coded as an *accurate source identification* (hereafter referred to as 'accurate') if the detail provided by the child was from the event being discussed. If the child reported the detail from the alternate event, it was coded as a *source confusion*. Reporting a detail that was not in either event was counted as an *external intrusion*, and *do not know*s were counted as such. Given the straightforward coding of these data, interrater reliability was 96.7% and all errors were resolved by discussion between coders.

Results

The number of accurate responses, source confusions, external intrusions, and do not know responses to the cued recall questions were each entered separately as the dependent variable into a 2 (Age: 3–4 year-olds, 6–8 year-olds) × 3 (Condition: Difference, Memory control, No-instruction control) between-subjects analysis of variance (ANOVA). The means and standard deviations are presented in Table 1.

Accuracy. Regarding accurate responses, there were no main effects of Age, $F(1, 85) = 2.56$, $p = .114$, or Condition, $F(2, 85) = 1.01$, $p = .37$, but there was a significant Age × Condition interaction, $F(2, 85) = 3.34$, $p < .05$, $\eta^2 = .08$. Follow-up independent samples t tests indicated that younger children in the No Instruction control condition were significantly less accurate than their older counterparts, $t(33) = -2.64$, $p = .013$, $d = 1.15$; see Table 1.

Table 1
Study 1 Means (Standard Deviations) for Children's Responses to the Cued-Recall Questions by Age Group and Condition

Age group	Condition	Children's responses: Accuracy	Source confusions	Intrusions	Don't know
3- to 4-year-olds	No instruction control	8.32[a] (3.08)	2.71 (1.58)	5.89 (2.39)	2.64 (2.59)
	Memory control	10.38 (2.20)	3.38 (1.51)	5.00 (1.51)	1.88 (2.95)
	Difference	9.22 (2.86)	2.44[b] (.88)	4.78 (2.17)	3.67 (2.24)
	Total	8.87 (2.95)	2.78 (1.46)	5.51 (2.23)	2.71[c] (2.59)
7- to 8-year-olds	No instruction control	11.86[a] (3.53)	2.86 (.38)	4.43 (3.21)	1.14 (.69)
	Memory control	10.16 (2.17)	2.63 (1.64)	5.58 (1.98)	2.26 (2.28)
	Difference	9.13 (2.62)	3.80[b] (1.32)	5.47 (2.42)	1.47 (1.60)
	Total	10.07 (2.70)	3.10 (1.46)	5.34 (2.35)	1.78[c] (1.88)

Note. Superscripts that share the same letter were significantly different from each other, $p < .05$. Maximum score is 21.

Source confusions. There were no main effects of Age, $F(1, 85) = 0.52$, $p = .47$ or Condition, $F(2, 85) = 0.32$, $p = .73$, but there was a significant Age × Condition interaction for *source confusions*, $F(2, 85) = 3.08$, $p = .05$, $\eta^2 = .07$. Follow-up independent samples *t* tests indicated that older children in the Difference Training condition reported, unexpectedly, significantly more source confusions than their younger counterparts, $t(22) = -2.73$, $p = .012$, $d = 1.20$; see Table 1.

External intrusions. No significant main effects or interactions were found for the external intrusion responses, $F\text{s} < 1.56$, $ps > .10$.

Do not knows. There was a significant main effect of Age for Do not know responses, $F(1, 85) = 3.97$, $p = .05$, $\eta^2 = .05$. The younger children responded significantly more often with 'do not know' than their older counterparts; see Table 1. There was no effect of Condition, $F(2, 85) = 0.53$, $p = .59$ and no Age × Condition interaction, $F(2, 85) = 1.95$, $p = .20$.

Discussion

Without specific instructions, typical age effects were found such that younger children were less accurate overall than older children (seen in the analyses on accurate responses and do not knows). Encouraging children to remember the events as best they can (memory control condition) did not improve their accuracy beyond merely drawing attention to target items (no-instruction control).

The fact that children who received the most explicit source-monitoring instruction (i.e., those in the Difference condition for whom differences between sources was emphasized), were no more accurate than children in the Memory control condition (who were instructed to pay attention but without any mention of differences between events) indicates that explicit encoding of unique source-specifying information is not enough to improve source attribution above and beyond instructions to pay attention.

The Difference training did have an effect on source confusions; however, it was not in the expected direction. Older children in the Difference training condition reported *more* source confusions than younger children, in contrast to most studies of source monitoring where younger children are more confused about source than older children (see Roberts, 2002, for a review). Although unexpected, this result was quite strong (Cohen's *d* was 1.20) and is quite consistent with research on children's memories of repeated events (more than two similar events). In repeated event studies, children are able to mention an average of 3 out of 4 variations of a detail when each of four events included a different variation yet are confused as to which events the details came (Powell et al., 1999). Thus, repetition enhances memory for content, but does not help to tag the details to their sources (see also Brubacher et al., 2011). Thus it is plausible that, in the current study, older children did indeed encode the differences between the two events, so much so that they had improved memories of the actual differences *from both events*. In other words, these children may have more easily retrieved the two parallel details (e.g., flag badge, ship badge) than other children. As they were unable to identify the source of each detail, they simply reported one of the two details they easily remembered. It is as if encoding unique information (differences) from the events improved memory for content, but not for source. In Study 2, we examine the effect of instructing children to bind this improved memory for details with the respective sources.

Study 2

Even though children clearly remembered the unique information from the events in Study 1, the *binding* of details with their sources may have been weak. Binding content and source appears to be a much more difficult task than just encoding source and content separately (e.g., Lloyd et al., 2009). To test this binding hypothesis, in Study 2, we altered the Difference training to a *Difference-Tag* manipulation. The point of the Difference-Tag condition was to support binding of the differences with the corresponding source. Thus, children were instructed to not only encode differences but to concurrently encode the source along with each difference. We hypothesized that the unique differences would be more closely bound to the source than with no special training, and thus result in enhanced accuracy and source monitoring of the two events (because retrieving the detail would also result in retrieval of source information).

Method

Participants. Again, we included a very young group of children, given that this is when the frontal lobe development and corresponding improvement in working memory, executive function, and source monitoring occurs, and older children for comparison. To more precisely understand the developmental process of source monitoring we divided the 94 participants into three age groups. The final sample comprised 3- to 4-year-olds ($N = 31$; $M = 48.20$ months, $SD = 6.32$), 5- to 6-year-olds ($N = 33$, $M = 71.12$ months, $SD = 7.34$), and 7- to 8-year-olds ($N = 30$, $M = 96.30$ months, $SD = 7.74$).

Procedure. The procedure was the exact same as Study 1 with the exception of the event encoding instructions. Children in each of the three age groups were randomly assigned to one of two encoding conditions. In the *Difference-Tag* condition children received a general instruction of

> I want you to watch what happens really carefully today. I'm going to dress up as a [**cowgirl**/doctor]. I'm going to dress up as a [**doctor**/cowgirl] on a different day and some things will be different. So watch really carefully today so you will remember what happened the day I was a [**cowgirl**/doctor]. OK?

Following this, each of the 21 differences was deliberately 'tagged' to its corresponding source to improve binding of content and source. For example,

> Here's your badge. It's a *flag* badge because it has a picture of a flag on it. I'm going to put the flag badge on your cape. Next time, it will be a different badge, so remember that you wore the *flag* badge *the day I was a* [**cowgirl**/*doctor*].

In the Control group, children were asked to pay attention but there was no mention of the differences between events. Children received a general instruction of, "I want you to watch what happens really carefully today. Today I'm going to dress up as a [**cowgirl**/doctor]," followed by noting each of the 21 items. For example, "Here's your badge. It's a *flag* badge because it has a picture of a flag on it. I'm going to put the flag badge on your cape."

Table 2
Study 2 Means (Standard Deviations) for Children's Responses to the Cued-Recall Questions by Age Group and Condition

		Children's responses			
Age group	Condition	Accuracy	Source confusions	Intrusions	Don't know
3- to 4-year-olds	Control	4.00 (3.12)	1.94 (1.39)	3.50 (2.45)	8.13 (4.43)
	Difference-tag	5.20 (3.71)	2.27 (1.67)	2.33 (1.95)	7.20 (5.31)
	Total	4.58^{a} (3.41)	2.10^{c} (1.51)	2.94 (2.27)	7.68^{ef} (4.81)
5- to 6-year-olds	Control	9.00 (4.23)	4.00 (2.29)	4.12 (2.83)	3.53 (1.84)
	Difference-tag	11.63 (4.11)	2.88 (1.54)	2.44 (1.90)	3.94 (3.32)
	Total	10.27^{a} (4.31)	3.45^{c} (2.02)	3.30 (2.53)	3.73^{e} (2.63)
7- to 8-year-olds	Control	12.07 (2.92)	3.07 (2.37)	2.33 (2.47)	2.87 (2.26)
	Difference-tag	13.47 (3.18)	1.87 (1.36)	2.40 (1.72)	3.07 (2.63)
	Total	12.77^{a} (3.08)	2.47 (2.00)	2.37 (1.71)	2.97^{f} (2.41)
Total collapsing Age Groups	Control	8.29^{b} (4.77)	3.02 (2.20)	3.35^{d} (2.47)	4.85 (3.80)
	Difference-tag	10.13^{b} (5.07)	2.35 (1.55)	2.39^{d} (1.82)	4.72 (4.22)
	Total	9.19 (4.98)	2.69 (1.93)	2.88 (2.22)	4.79 (3.99)

Note. Superscripts that share the same letter were significantly different from each other, $p < .05$. Maximum score is 21.

Results

The number of accurate responses, source confusions, external intrusions, and do not know responses to the cued-recall questions were each entered as the dependent variable separately into 3 (Age: 3–4, 5–6, 7–8 years) × 2 (Condition: Difference-Tag, Control) between-subjects ANOVAs. Scheffé tests were used to follow up the effects of age, $\alpha = 05$. The full set of means is presented in Table 2.

Accuracy. A significant main effect of Age, $F(2, 93) = 41.64$, $p = .00$, $\eta^2 = .49$, was found indicating that 7- to 8-year-olds provided a significantly greater number of accurate responses than the 5- to 6-year-olds, who in turn were significantly more accurate than the 3- to 4-year-olds; see Table 2. Additionally, a significant main effect of Condition was found, $F(1, 93) = 5.50$, $p = .02$, $\eta^2 = .06$, demonstrating that, as expected, children in the Difference-Tag condition produced a significantly greater number of accurate responses than did those in the Control condition. There was no significant Age × Condition interaction, $F(2, 93) = 0.37$, $p = .69$.

Source confusions. A significant main effect of Age, $F(2, 93) = 4.61$, $p = .01$, $\eta^2 = .10$, revealed that the 5- to 6-year-olds made significantly more source confusions than the 3- to 4-year-olds. There was no difference in scores between the 5- to 6-year-olds and the 7- to 8-year-olds; see Table 2. There was a marginally significant trend of Condition, $F(1, 93) = 3.13$, $p = .08$, $\eta^2 = .03$, indicating that, as expected, children in the Difference-Tag condition made fewer source confusions than children in the Control condition. There was no significant Age × Condition interaction, $F(2, 93) = 1.74$, $p = .18$.

External intrusions. While there was no significant main effect of Age, $F(2, 93) = 1.41$, $p = .25$, $\eta^2 = .03$, there was a significant main effect of Condition, $F(1, 93) = 4.32$, $p = .04$, $\eta^2 = .05$. Specifically, children in the Control group intruded significantly more details than did children in the Difference-Tag group; see Table 2. There was no significant Age × Condition interaction, $F(2, 93) = 1.34$, $p = .27$.

Do not know. A significant main effect of Age, $F(2, 93) = 16.03$, $p = .00$, $\eta^2 = .27$, revealed that the 3- to 4-year-olds responded to significantly more questions with a do not know response than either the 5- to 6- or 7- to 8-year-olds. There was no significant effect of Condition, $F(2, 93) = 0.20$, $p = .88$, and no significant Age × Condition interaction, $F(2, 93) = 0.33$, $p = .72$.

Discussion

The results of Study 2 show a clear superiority for both content and source when children are encouraged to bind them together at encoding. Children in the Difference-Tag condition who were given instructions like "Remember it was a *pirate* badge *the day I was a cowgirl*" subsequently responded to memory questions about one of the events with a greater number of accurate responses, intruded fewer details, and made fewer source confusions than children in the Control Condition. Remarkably, the benefit of content-source encoding extended to children of all ages, even very young children aged 3 to 4.

Typical age effects (in the absence of mentally- or physically-challenged children) were observed such that the youngest children (the 3- to 4-year-olds) responded with fewer accurate and more do not know responses than the older children, which gives validity to the measures and the finding of enhanced ability in the Difference-Tag condition.

There was one result that was somewhat unusual: the 5- to 6-year-olds made more source errors than the youngest children. Although most research on developmental differences in source monitoring has found a decrease in source confusions as age increases, there are other factors that play a role. Source-monitoring development is domain- and context-dependent (Johnson et al., 1993); distinguishing between what one has done and observed is achieved at an earlier point in development than is distinguishing between one's imagination and pretense (Welch-Ross, 1995). In research on source monitoring (Poole & Lindsay, 2002), mental-state understanding (Evans & Roberts, 2009; Welch-Ross, 2000), and categorization (Ratner, Foley, & Gimpert, 2002), older or more cognitively advanced children can show lower ability in source-monitoring skills than their less-skilled, younger counterparts. The most parsimonious explanation is that children at this age (note that 5- to 6-year-olds participated in all of the four studies just cited) are in a transitional stage where they are accumulating skills in source monitoring but have not yet been able to transfer these skills to all situations. Thus, the 5- to 6-year-olds in the present study may have made the most source errors because they were paying some attention to source but have not yet extrapolated domain-independence, though we cannot be sure of the actual reason for this finding.

General Discussion

Most research on source monitoring has focused on how decisions are made at retrieval, for example, elucidating the processes through which we examine the qualitative characteristics of memories to attribute source (e.g., Foley, Johnson, & Raye, 1983; Roberts & Blades, 1998; Thierry & Spence, 2004). As source monitoring is a process of attribution based on the qualitative characteristics of retrieved memories and other more systematic processes (Johnson et al., 1993), researchers have pondered what sort of difficulties children encounter when attributing source. Given the importance of the quality of retrieved memories on source attribution, however, it is reasonable to investigate how processes at *encoding* might affect source monitoring because what is retrieved is partly dependent on what was initially encoded (Lloyd et al., 2009).

In the current investigation, typical age effects in source monitoring were offset when children were encouraged to encode content and source jointly. This was not simply a matter of encoding or more reliable memory for content because children who were given specific instructions to pay attention and notice unique differences about events were no better than other children at reducing confusion between two similar events. In fact, in Study 1, these children were *more* confused, which we suspect was an undesirable artifact of improved memory for content (they remembered the actual content of both events—seen in improved accuracy for content—but had not encoded the source with the content—seen in increased source confusions). A more plausible explanation for the improved ability to identify the source of similar details across events was that, in the Difference-Tag condition, children encoded the details *together with their source*. This is an example of 'binding,' a cognitive process known to be correlated with source monitoring skills in children of this age (Lloyd et al., 2009). Until now, it was not known that children's source monitoring could be improved by explicitly encouraging them to bind content and source information.

How might such binding or 'tagging' of events to their sources help subsequent source monitoring? First, children may have directly encoded source when so instructed and thus directly retrieved source information. If the detail is bound tightly with its source, retrieval of the detail is more likely to also lead to retrieval of the corresponding source than if the detail was not tightly bound to source. Alternatively, the repetition of the source with each detail in the event may have provided children with a "label" for the event source, thus aiding retrieval because retrieving a label may spread to retrieval of features associated with the label (Brubacher et al., 2012; recall that the 'source' needed to be extracted rather than visually observed). A third possibility is that source may be more easily reconstructed if it was encoded in parallel with unique details. Thus, even if children did not directly remember source, the simultaneous coding may lead children to reason more systematically about the source (e.g., *she always talked about the cowgirl costume when it was the stripy scarf, so if she asks me about the stripy scarf, it must have been the cowgirl time*). Further research that systematically teases apart these hypotheses is warranted.

What might underlie age improvements in encoding and retrieving source? Younger children remember less than older children because of limitations in storage capacity (e.g., Cowan, 2001), rehearsal rate (e.g., Schneider & Bjorklund, 1998), or retrieval mechanisms (Sophian & Hagen, 1978). The younger children in the current research are also likely to be experiencing significant frontal lobe development and, subsequently, development in their ability to hold multiple items in working memory and use executive functions to make source-monitoring decisions (e.g., inhibitory control, Earhart & Roberts, 2014; Roberts & Powell, 2005). Immature hippocampal areas (where activation is especially strong when items and sources are bound together) may mediate these patterns. Even withstanding these developmental changes, the benefits of binding content and source did not interact with age in the current research. Hence, children in the Difference-Tag condition of Study 2 were more accurate than other children, regardless of their age. This is consistent with studies that have tested manipulations at retrieval for 7- to 8-year-olds (e.g., Poole & Lindsay, 2002) and 3- to 4-year-olds (Thierry & Spence, 2002) and found that source monitoring could be improved. The current research shows that even in the absence of training at retrieval, source monitoring can be improved through enhancement of encoding processes. Thus, the brain development of children in this study may not have been sufficient enough to spontaneously monitor sources accurately by binding item and source features together. Or even if they did bind content and source initially, there may have been some disintegration over the delay. However, the important point is that with binding instructions at the encoding stage, children were able to improve the accuracy of their source monitoring. In other words, these children had the capacity to monitor sources accurately by binding even though without instruction they performed like adults with compromised frontal lobe functions. This highlights the sensitivity of growth in these brain areas and provides strong encouragement to researchers to persevere with investigations of children's (as opposed to adults') neural development. In particular, growth between ages 3 and 8 years seems a particularly important phenomenon.

The results might further our understanding of other types of children's memories. First, our autobiographical memories come from complex experiences rather than constructed test materials. Encoding processes are of particular relevance for actual events as children may encode those parts of the events that have some significance to them. In the current study, we chose to assess memories of naturalistic events to ensure that effects seen from simpler lab tasks are indeed typical of those from 'real-life' events. Second, the results may help us understand memories of events that are repeated many times. It is well known that children can remember details from individual occurrences for events but still be confused as to which occurrence they belong to (Powell et al., 1999). In one study, most of the details children reported were presented at some point over four occurrences of a repeated event and there were very few intrusions of details that were never presented. Children were confused, however, as to which details came from which occurrence, even though they remembered that they had happened (Powell et al., 1999). Yet researchers have made little progress in understanding the mechanisms that are needed to reduce such source confusions (Roberts, 2002). The results of the current research suggests that perhaps what underlies the confusion is a failure to bind source and content together at encoding, store the information, and/or reconnect the bound information if source and content separate over time.

The study results may also shed light on developmental differences between incidental and intentional learning. The information encoded by children in the control groups of this study may be attributable to *incidental* encoding (i.e., information that is automatically encoded without effort). The children who were given explicit instructions, in contrast, were likely to have been *intentionally* encoding the details (see Hockley, Ahmad, & Nicholson, 2016) and, in particular, intentionally binding item and source information. Importantly, these children were able to improve their source monitoring by engaging in these intentional processes and so we can conclude that, at this age, they were cognitively prepared to engage in accurate source monitoring, even though they may not do so automatically.

The exact mechanism of how source monitoring improves over development has intrigued researchers. Often source and memory accuracy are dissociated (as in studies of repeated events, e.g., Connolly & Lindsay, 2001; Powell et al., 1999); yet in other studies it seems that children can directly retrieve source (e.g., Lloyd et al., 2009). Even if source is attributed (rather than retrieved) at test, the quality of the memory trace (e.g., vividness, decay of perceptual information, lack of source-specifying information) must have some impact on subsequent source-monitoring decisions. The empirical demonstration of improved source monitoring seen in this study when source and content were bound together at encoding, together with the research by Newcombe and colleagues (e.g., Crawley, Newcombe, & Bingman, 2010; Lloyd et al., 2009) is beginning to elucidate some mechanisms that can contribute to the formulation of a testable theory of source-monitoring development. In conclusion, the results presented here promote promising new avenues to explore in cognitive and neural research on the developmental pathway of source monitoring.

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(*Appendices follow*)

Appendix A

Photography Event Script A (Cowgirl)

Introduction and rapport building

1. Photographer shakes children's hands, introduces herself and invites children to sit down.
2. Photographer asks children their names.
3. Photographer engages in a group discussion about what they were just doing in class.
4. Photographer explains that they will be dressing up in costumes and having their photographs taken.
5. Photographer shows children pictures of pirates and cowboys from children's books.

Children dress up

1. Pirate costumes comprise of a white cloak, a belt with spots, an eye patch, a ship badge.
2. Photographer ties a cape around each child.
3. Photographer pins ship badge on right side of child's cape.
4. Photographer puts belt on child.
5. Photographer puts eye patches on children's left eyes.
6. Child chooses hat from box and photographer puts on child.

First photograph

1. Photographer takes a photo of each child individually.
2. Photographer shows children how to salute; asks them to say "sausages" for the photograph.
3. Repeat with other children.

Photographer dresses up

1. The cowboy costume comprises a vest, sheriff's badge, scarf, cowboy boots, hat.
2. Photographer invites each child to pick out an item from a box.
3. Child helps Photographer dress in each item; photographer asks children's name again and says "so [Jennifer] is helping me put on my boots".
4. The photographer pins the sheriffs' badge on the vest pocket.

Second photograph

1. Photographer sets the timer on the camera and explains what she is doing with the timer.
2. Photographer chooses a child at random and asks them to hold their hat. "Adam is holding my hat while I set the timer".
3. Photographer asks children to say "sausages" for the photograph.
4. Photographer and children have their picture taken together.

Removing costumes

1. The photographer removes the children's hats and puts in box.
2. Photographer removes eye patch.
3. Children remove their belts.
4. Photographer removes the badges.
5. Photographer unties the capes, children remove them, and put them in the cape box.
6. Photographer chooses a child at random and asks her/him to take off the cowboy vest.
7. Photographer removes own badge, scarf, and boots.

Conclusion

1. Photographer promises children that they will get the photos back when they are ready.
2. Photographer puts on guitar music and tells children that this music relaxes her.
3. Photographer explains that she is going to the movies tonight.
4. Photographer thanks children for their help.

(*Appendices continue*)

Appendix B

Twenty-One Target Items

Detail	Event: Cowgirl	Event: Doctor
1	Shake hand at beginning	Shake hand at end
2	Showed children a Book	Showed children a Video
3	White cloak	Black cloak
4	Belt with spots	Belt with stripes
5	Ship badge	Flag badge
6	Badge was black	Badge was red
7	Put eye patch on left eye	Put eye patch on right eye
8	Selects own hat	Selects own pirate badge
9	Selects from box	Selects from glass jar
10	Child gets to select a cowgirl costume piece	Child gets to select a Doctor costume piece
11	Brown shoes	Red shoes
12	Photographer has a star badge	Photographer has a clock badge
13	Photographer pins badge on vest	Photographer pins badge on lab coat
14	Child Salutes when photo is taken with photographer	Child Waves when photo is taken with photographer
15	Child A holds photographer's hat for picture	Child B holds photographer's stethoscope
16	Child says "bananas" when photo is taken	Child says "sausages" when photo is taken
17	Photographer removes child's badge	Child removes their own badge
18	Child removes their own belt	Photographer removes child's belt
19	Child X helps the photographer take off their vest	Child Y helps the photographer remove their lab coat
20	Listen to guitar music	Listen to piano music
21	Photographer tells children that she is going to the movies	Photographer tells children that she is going to a birthday party

Appendix C

Interview Questions

Children were directed to think about a specific day [either cowboy or doctor] and were reminded of the day on every third question (e.g., "What color cape did you wear, the day she was a [cowgirl/doctor]?")

1. When did she shake your hand?
2. I heard that you looked at pictures of pirates and cowboys/doctors. Where were the pictures?
3. What color cape did you wear?
4. What color was your badge?
5. What was on your badge?
6. Show me which eye she put the eyepatch on.
7. What was on your belt?
8. Where did you get your hat (Cowgirl event)/badge (Doctor event) from?
9. I heard that she sometimes let children pick part of their costume. What did she let you pick?
10. What did you choose for the photographer to wear?
11. What color were the photographer's shoes?
12. Where did the photographer pin her badge?
13. What was her badge like?
14. Who held her hat when she got the camera ready?
15. Show me what you did with your hands in the photographs.
16. What did you say for the photographs?
17. Who took off your hat?
18. Who took off your belt?
19. Who helped her take off her vest/lab coat?
20. Where did the photographer say she was going that night?
21. What music played when you were getting ready to go back to class?

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