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Developmental Differences in the Ability to Provide Temporal Information About Repeated Events

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Summary: Children (n = 372) aged 4–8 years participated in one or four occurrences of a similar event and were interviewed 1 week later. Compared with 85% of children who participated once, less than 25% with repeated experience gave the exact number of times they participated, although all knew they participated more than once. Children with repeated experience were asked additional temporal questions, and there were clear developmental differences. Older children were more able than younger children to judge relative order and temporal position of the four occurrences. They also demonstrated improved temporal memory for the first and last relative to the middle occurrences, while younger children did so only for the first. This is the first systematic demonstration of children's memory for temporal information after a repeated event. We discuss implications for theories of temporal memory development and the practical implications of asking children to provide temporal information.

Events that occur on a repeated basis are part of everyday experience (e.g., going to work or school) and tend to be highly similar, although particular episodes may include unique details. Unfortunately, some children experience negative events such as bullying or abuse that occur on a regular basis and often have similar characteristics across occurrences. Children typically find it challenging to distinguish and discuss a single occurrence of a repeated event (e.g., Powell, Roberts, Ceci, & Hembrooke, 1999; Roberts & Powell, 2001), although older children tend to have less difficulty than younger children when attributing details to individual occurrences (e.g., Farrar & Boyer-Pennington, 1999). Nonetheless, in many jurisdictions, children who allege repeated abuse are required to particularize, or discuss specific instances of an event with an adequate degree of precision in reference to time, place, or other unique contextual detail, and are often questioned about the frequency of repeated events, in order for an investigation to proceed (*S v. R*, 1989; see Powell, Roberts & Guadagno, 2007). Although there is much literature concerning children's temporal memory for a past event that happened only once (e.g., Friedman, 1991; Friedman & Lyon, 2005; Friedman, Reese, and Dai, 2011), and even their temporal estimations of future events (Busby Grant, & Suddendorf, 2009; Hudson & Mayhew, 2011), we know less about children's temporal memory for similar events experienced repeatedly. Thus, the current study aimed to address this gap in the literature.

In order to determine which specific details match which temporal occurrence following repeated experience (e.g., 'Did it happen in the kitchen the *last* time, or was that another time?'), children must determine the *sources* of their memories (Johnson, Hashtroudi, & Lindsay, 1993). Such decisions are difficult for children, especially when the events are similar (Lindsay, Johnson, & Kwon, 1991; Roberts, 2002). The temporal source of memories can become dissociated from, the sometimes well preserved, memories of the actual content of events (e.g., Friedman et al., 2011; Powell & Thomson, 1997; Wandrey, Lyon, Quas, & Friedman, 2012), possibly because memory for temporal information involves reconstructive processes (figuring out the time of events based on memories of the events), while memory for content generally does not involve such processes as extensively (Friedman, 2004; 2007).

There are also clear developmental differences in the ease with which children can bind together information from one source (e.g., Crawley, Newcombe, & Bingman, 2010). According to this approach, events are confused because distinctive details are not bound together with useful source-specifying information (e.g., temporal details). Successfully retrieving temporal information, then, can highlight the unique context of the to-be-remembered instance and thereby allow successful distinction between sources. A systematic analysis of the sorts of temporal information children can remember with respect to repeated occurrences of an event, however, has not yet been reported until now.

In practice, children are often asked whether an event happened one time or more than one time (Orbach & Lamb, 2007), to report the exact frequency of the events (Guadagno & Powell, 2009), to estimate how old they were at the time (U.S. v. Tsinhnahijinnie, 1997), to estimate what date, day, or time of day events occurred, to report the order of details across occurrences of events (Guadagno & Powell, 2009), and to judge the timing of events either in relation to temporal landmarks such as holidays (as in KAW, 1986; cited by Friedman & Lyon, 2005) or in relation to other critical events of the case. For example, in a Canadian study of court cases (Park & Renner, 1998), an 8-year-old child witness was asked, 'Do you know how long it was, the day before you went downstairs to get the bicycle horn, that you had last seen Mr. R.?' Undoubtedly, there are more problems with this question than just the requirement to estimate time (beyond the scope of this report but equally critical in understanding the difficulties faced by children in the legal system), but it illustrates well the need to characterize children's

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abilities to sequence multiple-related events in time. On several known occasions, children's testimony was called into doubt because they were unable to specify event frequency (e.g., see Lyon & Saywitz, 2006; Det. Cst. B. Doherty, personal communication, 17 May 2011), and children's ability to provide temporal information such as when events occurred can make their testimony more valuable (Orbach & Lamb, 2007).

Not only may children be tasked with providing temporal information beyond their abilities, but when children make allegations of repeated abuse, the risk of temporally suggestive questions increases (e.g., 'tell me more about the touching game that happened when you saw him last week'; when both the content and temporal references are accurate but did not occur together), and children find these types of questions more challenging than questions that suggest content alone (Powell et al., 2007). Thus, it is vital to understand how accurately children with repeated experience are able to determine how many times an event occurred and to sequence information *across* individual occurrences, in the absence of suggestive or highly complex questioning. The current study examines the accuracy of children's temporal judgments about specific details that occurred during a set of four repeated lab events, following open-ended interviews about those events. Research on children's temporal abilities and theories related to temporal memory will be briefly reviewed in advance of presenting the study hypotheses.

The development of temporal memory

There are three broad categories of theories of temporal memory. *Distance* theories posit that judgments about the time of memories are made based on how long ago the event happened. *Location* theories focus on temporal judgments derived from remembering locations in time, such as the day, season, or specific year an event occurred. Adults generally integrate their knowledge of *location* and *distance* cues to reconstruct temporal memory (Friedman, 1991; Friedman, Gardner & Zubin, 1995; Friedman & Kemp, 1998). There are developmental differences, however, in the acquisition of knowledge about *distance* and *location* concepts among children. For example, preschool-aged children make distance judgments without cognitive access to location information, but first-grade and third-grade children can use knowledge of temporal location patterns to assist them in determining when an event occurred, at least with respect to a day (e.g., recalling that if an event happened after afternoon recess, it could not have happened in the morning; Friedman, 1991; Friedman, et al., 2011). Finally, *order code* theories suggest that the temporal sequence of events is established when a second event reinstates an earlier event. Children tend to be more successful in ordering elements *within* an event the more logically connected are the elements (Fivush & Mandler, 1985). *Order code* theories may be particularly applicable to repeated-event memory if individual occurrences of repeated events reinstate the other occurrences, but this is not yet known. By age 6, children can accurately recall the order of two unrelated events (Friedman & Lyon, 2005; Pathman, Larkina, Burch, & Bauer, 2013), but whether this ability corresponds to ordering a greater number of events, and events that are associated with each other, is unclear.

Temporal metamemory, which refers to an understanding of those features that are common to content and temporal memory, and those that are specific to one's memory for when events happened, develops throughout childhood and adolescence (Friedman, 2007); thus, young children are likely to find it more difficult than older children and adults to make temporal decisions. Indeed, Friedman and Lyon (2005) found that even though children as young as 4 years old might identify useful temporal information, they may not be able to effectively use that information to make temporal judgments until age 6 (e.g., children did not make use of 'landmark' events), and Tartas (2001) reported a developmental improvement in using conventional temporal location concepts (e.g., days, weeks, and months) to answer questions about when events happen prior to developing a full understanding of these terms (e.g., 'Sunday' represents a day off school and 'Monday' represents a school day, even though the actual days might be Saturday, another non-school day, and Tuesday, a school day). Further, children's spontaneous and responsive reports of temporal information increase with age (Orbach & Lamb, 2007), although they use temporal terms (e.g., reciting the days of the week) before they have a conceptual understanding of their meaning (Poole & Lamb, 1998).

Temporal memory for repeated events

There is very little documented research addressing the ability of children with repeated-event experience to make temporal judgments despite the fact that this is a common task and one that can be vitally important in forensic interviews. In these cases, locating events in time and providing details specific to an event can be of the utmost importance. We cannot assume that the current literature on children's temporal recall of a single event, or two unrelated events, maps onto recall of a repeated event. A large body of literature shows, in fact, that memories of once-experienced events differ from memories of repeated events (see Roberts & Powell, 2001, for a review). For example, following repeated experience, children develop 'scripts' concerning what typically happens during the events, and there are developmental differences in the speed at which these scripts are confirmed (i.e., understanding which elements are part of the script) and then later deployed (i.e., being able to notice elements that are script inconsistent) (see Farrar & Goodman, 1990; 1992). This process is relevant to temporal memory for repeated events because it suggests that the first experience should be memorable; it should stand out because the details have not been absorbed into the event script. Additionally, a later experience (such as the last time) should also be enduring, especially for children who have reached the deployment phase.

A few studies provide insight as to how children will perform when asked to provide temporal details about a repeated event. Recent work by Sharman, Powell, and Roberts (2011) demonstrated that children are able to make accurate frequency determinations after participating in an event only once. Conversely, children who experienced repeated, similar events had difficulty providing a specific estimate of how many times the event occurred (although they did recall that it had happened more than once; see also Guadagno & Powell, 2009; Wandrey et al., 2012). Research examining children's sequencing ability has centered on how young children order details *within* rather than across events (e.g., Bauer, 1992; Bauer & Mandler, 1989; Hudson & Nelson, 1983). For example, there are developmental differences in children's ability to accurately order the steps of a familiar event such as eating at a restaurant, with 5- and 6-year-olds outperforming 4-year-olds (Fivush & Mandler, 1985). However, some research demonstrates that children as young as 4 years old are able to accurately sequence two past events when asked about which one occurred more recently if the events are widely spaced relative to their temporal distance in the past (e.g., Friedman, 1991; Friedman & Lyon, 2005). Nonetheless, when children are asked to make a decision about which of a series of similar details took place during the final occurrence of a repeated event, they have difficulty attributing the correct detail (Powell, Thomson, & Ceci, 2003). Clearly, the scant results so far imply that children's memories of the *temporal characteristics* of repeated events should also differ markedly from those of single events.

Current study and hypotheses

In the current study, 4- to 8-year-old children participated in one or four sessions of a scripted event that was highly similar each time. Children were later interviewed about the events and were asked how many sessions they experienced. In line with previous research on children's frequency judgments (e.g., Sharman et al., 2011), we expected that older children and those who participated once would provide more accurate frequency judgments than younger children and those who participated repeatedly.

Children with repeated experience were given three additional temporal tasks. The study did not aim to directly test location, distance, or order code theories as we have thus far limited understanding about children's ability to provide temporal information about repeated events. Instead, we attempted to add to existing knowledge about the information that children can provide in response to three question types: relative order, position in a sequence, and serial order. Children were asked the following: (i) To decide whether the target occurrence (referred to by the child's label) happened *before* or *after* the first and last occurrences (order counterbalanced). The target occurrence was referred to by a specific detail from that occurrence [e.g., 'did the time you sat on a garbage bag (target occurrence) happen before or after the day you heard a story about a dog?'] (*Relative Order task*). (ii) To report the temporal position of details from the occurrences (i.e., 'which badge did you get on the third day? The second day?' etc.) (*Temporal Position task*). And (iii) to place details from each occurrence in the correct order according to when they happened (i.e., 'place the story you read first here, the second here…' etc.) (*Serial Order task*).

On the whole, older children were expected to be more accurate than younger children given previously reported developmental differences in memory for repeated events (e.g., Connolly & Lindsay, 2001; Farrar & Boyer-Pennington, 1999; Friedman & Lyon, 2005; Powell et al., 1999). Consistent with Powell and colleagues (2003), we predicted that older children would be better able to identify the Position and Order of the first and last occurrences, relative to the middle two. Although Powell and colleagues (2003) found that older children's performance for the last occurrence declined over a long delay, while their memories for the first occurrence were unaffected by delay, the delays used in the current study were relatively short, so we anticipated performance to be similar for the first and last occurrences among the older children. Insight into the performance of the younger children was limited but consistent with the schema confirmation-deployment model (Farrar & Goodman, 1990), and for the finding that young children became more confused about the temporal placement of details with increasing event experience (Farrar & Goodman, 1992), we predicted that the 4- to 5-year-old children would perform better only on the first occurrence relative to the other three. Finally, when children erred, we expected the distance between the erroneous and true occurrence to be smaller for the older than younger children (e.g., Gosse & Roberts, 2013; Hudson & Mayhew, 2011).

METHOD

Design and participants

Data for this study were obtained from four very similar experiments that focused on the characteristics of details provided during children's free narratives of repeated events (Brubacher, Glisic, Roberts & Powell, 2011; Brubacher, Roberts & Powell, 2011; Brubacher, Roberts & Powell, 2012; Drohan-Jennings, 2010). In these studies, children participated once or four times in a set of activities (twice per week on non-consecutive days, for 2 weeks) and were interviewed 4–7 days after the final (or only) event. In general, and in keeping with previous research, children with repeated experience made more errors than children with a single experience because the former confused details from the four occurrences (further details on the narrative reports can be found in the reports listed earlier).

Importantly, a battery of temporal tasks was given to children following the free narrative, and these data were not included in publications. Thus, the data on temporal memory reported here are novel. The benefit of combining data from these four highly similar studies is that it provides a very large sample ($N = 372$) to test the novel issue of children's temporal memory following repeated experiences. The database for the current study comprised a 2 (Age Group: 4–5, 6–8-year-olds) $\times$ 2 (Event Frequency: Single or Repeated) between-subjects design with 372 children (190 and 182 in the Single and Repeated conditions, respectively; 184 females, 188 males; see Table 1 for mean ages).

Materials

The same props modeled on those used in previous research (e.g., Roberts & Powell, 2005, 2006) were used for all four

Table 1. Mean age in years of participants in the dataset, by study and age group

Study	Age group	Age in years		N
		M	*SD*	*N*
Brubacher, Glisic, Roberts, and Powell (2011); repeated	4–5-year-olds	4.61	0.50	18
	6–8-year-olds	7.45	0.51	20
Drohan-Jennings (2010); repeated	4–5-year-olds	4.63	0.55	35
	6–8-year-olds	6.79	0.89	33
Brubacher, Roberts, and Powell (2012); repeated	4–5-year-olds	4.43	0.50	40
	6–8-year-olds	7.44	0.50	36
Brubacher, Roberts, & Powell (2012); single	4–5-year-olds	4.44	0.56	34
	6–8-year-olds	7.53	0.51	36
Brubacher, Roberts, and Powell (2011); single	4–5-year-olds	5.67[a]	0.47	61
	6–8-year-olds	7.39	0.56	59

[a]4-year-olds were not included in Brubacher et al. (2011).

studies, were counterbalanced, and were designed specifically for the research. Across studies, the activities were the same (e.g., a clown puzzle), but the specific detail (instantiation) remained the same or changed with varying frequency across event sessions (e.g., the clown was juggling one time, on a tightrope another time; see Appendix). Details could either be *fixed* (the same instantiation in all sessions), *variable* (a different instantiation each session), *hi/lo* (same instantiation in three sessions and an alternative instantiation in one), or *new* (present in only one session across the series). Note that across the experiments, different activities were assigned to detail types so that an activity that was *fixed* in one experiment may have been *hi/lo* in another experiment. Thus, item effects cannot underlie the results reported later.

Procedure

Events

The scripted event sessions lasted 20 minutes each and were led by trained research assistants (RAs). Children participated in the activity sessions in groups of up to 10 children. See Appendix for a full list of the possible activities (items) that could occur within event sessions and all of their possible instantiations.

Memory interview

Interviews were conducted 4–7 days after the final (or only) event session, lasted approximately 30 minutes, and were conducted by trained RAs who did not lead the event sessions and were naïve to the study purposes as well as children's participation frequency. Children were interviewed individually using open-ended questions (e.g., *What happened next*?) and were then asked the temporal questions that are the focus of the current study. They were asked to talk about a specific occurrence of their choosing [except in the Drohan-Jennings (2010) study when children were asked to talk about the last occurrence]. The children's chosen target occurrences were labeled with an instantiation provided by the child (e.g., 'the time with the jellybean badge') or a temporal term if the child had used it (e.g., 'the first time'). All children were asked about participation frequency, and then children with repeated experience completed three additional temporal tasks. Presentation of the Relative Order, Temporal Position, and Serial Order questions was counterbalanced across children, with the exception that the Temporal Position and Serial Order questions were always asked as a pair (with the Relative Order question either preceding or following the other two). There was no difference in the number of correct responses to any of the questions based on presentation order ($F\text{s} \leq 1.33$, $p\text{s} \geq .24$, $\eta^2 \leq .07$). Immediately prior to the Temporal Position and Serial Order questions, children were also given a set of four colored blocks and asked order questions about them (e.g., 'which block is third?') to give them practice in how to complete the tasks in the absence of a memory component.

Question about participation frequency. Children [excluding those in the Drohan-Jennings (2010) study] were asked whether the Activities happened one time or more than one time. If the response was 'more than one time', they were asked to report the number of times. Coders recorded the number reported, or that the child responded 'don't know'.

Relative Order question. Children were asked whether the target occurrence happened before or after (order counterbalanced) an instantiation from the first occurrence of the Activities, as well as from the last occurrence [*Did the time* (*target occurrence*, *e.g.*, *you sat on a garbage bag*) *happen before or after the time you* (*instantiation from first/last occurrence*, *e.g.*, *heard a story about a dog*)?]. Children whose labels corresponded to the first or last occurrence were not asked the congruent Relative Order question (i.e., children talking about the 'first time' were not asked whether an instantiation happened before or after the first time) because the question is misleading. Thus, children with temporal labels 'first' or 'last' time are not included in the analyses for the respective Relative Order question only (i.e., children who described the first occurrence were asked the location question only about an instantiation from the last occurrence). Children were also not asked the Relative Order question if they did not remember the instantiation to be queried (they were asked first whether they remembered the instantiation). Children's responses were coded as correct, incorrect, or 'don't know'. In Drohan-Jennings' (2010) study, all children were asked to describe the last occurrence, and so these children were asked about instantiations that happened in the first and *third* occurrences.

Temporal Position question. Children were shown photographs of all four possible instantiations of a detail that, while always present, changed across the series (chosen randomly). The interviewer laid out the photographs in an arbitrary order and asked the child to point to the instantiation that happened first, second, and so on [e.g., '*Here are pictures of each of the puzzles you made at the Activities. Please point to which one came first.* (after child responds) *Now point to which one came third…fourth…second*'; order of questioning was randomized]. Children's responses were coded as correct if they correctly pointed to the instantiation being queried, giving a maximum possible score of four.

Serial Order question. Another detail that varied was randomly selected (these details were assigned to the Temporal Position or Serial Order question with approximately equal frequency). The child was given four photographs and asked to sort them in the positions they occurred (e.g., 'Here are the pictures of each of the cloaks the leader wore at the Activities. Please put the one that came first here, the one that came second…third…fourth here'). Children's responses were coded as correct if they correctly positioned the instantiation that was present in each occurrence, giving a maximum possible score of four.

Distance assessment. In order to determine the distance between the actual occurrence of an instantiation and children's temporal report of that instantiation, a 4 (Actual Day) × 4 (Placement Day) matrix was created for each Age Group, for the Temporal Position and Serial Order questions. If a child, for example, correctly reported that the first instantiation happened on the first day, a tally mark was made in the Actual Day 1 × Placement Day 1 cell; but if they said the second day, a mark was made in the Actual Day 1 × Placement Day 2 cell, and so on. Past research (e.g., Powell et al., 1999) has shown that children are more likely to misattribute details from an occurrence of a repeated event that was close to the target event than from an occurrence that was farther in time from the target event.

Intercoder reliability

Cohen's Kappa was calculated for a random sample of 15% of interviews for the frequency question, and Relative Order, Temporal Position, and Serial Order tasks. Reliability was very high (Cohen's Kappa = 1.00) for all question types as expected because agreement between coders relied almost exclusively upon careful recording of what the child said or did (rather than making any subjective judgment). Percent agreement reliability was calculated for the linear distance coding and was 92% reliable (percent agreement was used for the linear distance matrices because we were simply assessing reliability for quantifying the number of observations in each cell of the matrix).

RESULTS

An alpha level of .05 was used unless otherwise noted. Although data were collected as part of several studies, in only one analysis was there an effect of Study. Details are provided later; otherwise, Study was removed from analyses (and results remained the same).

Frequency question

A 2 (Participation Frequency: Single or Repeated) × 2 (Accurate: Yes or No) chi-square was conducted and revealed a significant difference in accuracy as a function of frequency of participation, χ^2 (1, N = 300) = 114.61, $p < .001$, Cramer's V = .62. Of the 187 single-event children who reported the number of times they participated, 159 (85.0%) accurately identified that they had participated only once. Nine (4.8%) children said they did not remember how many times they participated, and nine (4.8%) said only that the activities happened more than once but did not provide an estimate of the number of times they took part. The remaining 11 (5.9%) children's incorrect responses varied, for example, reporting that the activities happened three times or six times.

None of the children in the repeated condition erroneously said they participated 'one time'. However, only 26 (23.0%) of the 113 repeated-event children who reported the number of times they participated accurately reported 'four times'. Many were off by one in their frequency estimate [nine (7.9%) children reported three, and 17 (15.0%) children reported five occurrences]. Thus, in total, 45.9% of the repeated-event children estimated that they participated three, four, or five times, and an additional 32 (28.3%) children with repeated experience admitted that they did not know. Only one-quarter of the children with repeated experience (n = 29; 25.7%) provided a variety of inaccurate estimates of the frequency of their participation, such as 'six or seven' or 'at least seven or eight' (five of those provided estimates of 10 or more).

To address age differences, separate 2 (Age Group: 4- to 5- or 6- to 8-year-olds) × 2 (Accurate: Yes or No) chi-square tests were conducted for the single-event and repeated-event children on their responses to the frequency question. Accurate responses from children in the single-event condition did not differ with age as 77 of the younger children (81.9%, n = 94) and 82 of the older children (88.2%, n = 93) accurately reported they participated only once, χ^2 (1, N = 187) = 1.44, p = .23, Cramer's V = .09. However, there was a significant age difference for children with repeated experience, χ^2 (1, N = 113) = 8.05, p = .005, Cramer's V = .27. Of the 58 younger children, only 7 (12.1%) accurately identified they did the Activities four times. However, 19 (34.5%) of the 55 older children accurately reported 'four times'. Examination of the frequencies of reports of three or five occurrences among repeated experience children indicated that the children were fairly evenly distributed across age groups. Of the nine children who reported that the Activities happened three times, five of them were younger children and four of them were older children; among those who reported five occurrences, eight of them were younger and nine of them were older children.

Relative Order question

To assess age differences, separate one-way analyses of variance (ANOVAs) were conducted for the proportion of accurate responses to the first and last instantiations. There were 37 children excluded from the analysis on the first instantiation: 17 had the temporal label 'first time', 13 did not remember the instantiation, one did not understand the question, and responses from six were excluded because of interviewer error in asking the question. Older children ($M = 0.65$, $SD = 0.48$) were more accurate than younger children ($M = 0.42$, $SD = 0.50$) for the first instantiation, $F(1, 132) = 7.12$, $p = .009$, $\eta^2 = .05$.

With respect to the last instantiation, 23 children had the temporal label 'last time', 11 children were excluded because they did not remember the instantiation, one did not understand the question, and four were excluded because of interviewer error. In contrast to the analysis on the first instantiation, there was no difference between the older ($M = 0.49$, $SD = 0.50$) and younger children ($M = 0.43$, $SD = 0.50$) for the last instantiation, $F(1, 128) = 0.57$, $p = .45$, $\eta^2 = .004$.

To compare children's performance to chance (to ensure that they were not merely guessing), we conducted one-sample *t*-tests for age group for each the first and last instantiations (corrected alpha = .0125). Chance was considered .50 for each instantiation because children could be either correct or incorrect about whether the given instantiation occurred before or after the target occurrence. The *t*-tests revealed that the younger children did not differ from the chance level for both the first ($M = 0.42$, $SE = 0.06$) and last ($M = 0.43$, $SE = 0.06$) instantiation ($ts \leq -1.16$, $ps \geq .19$, Cohen's $ds \leq -.16$). The older children were marginally above chance levels in providing accurate responses for the first instantiation, $t(64) = 2.45$, $p = .017$, Cohen's $d = 0.30$, but not for the last instantiation, $t(68) = -.12$, $p = .91$, Cohen's $d = -.01$.

Temporal Position question

The number of correct responses to the Temporal Position question (max = 4) was entered into a one-way ANOVA by Age Group. Older children ($M = 1.65$, $SD = 1.39$) outperformed younger children ($M = 1.34$, $SD = 1.00$) as we predicted, $F(1, 176) = 2.81$, $p = .05$, $\eta^2 = .02$ (one-tailed). Older and younger children's scores were compared to chance (25%) in two one-sample *t*-tests (alpha = .025) and found to be above chance, $ts \geq 3.28$, $ps \leq .001$, Cohen's $ds \leq 47$. Chance was evaluated at one out of four (or 25%) because there were four alternatives to choose from. Children's responses to each picture were not necessarily contingent upon their responses to each other picture (i.e., it was possible for them to point to the same picture more than once).

Serial Order question

A one-way ANOVA for Age Group on the number of accurate responses to the Serial Order question (max = 4) revealed a significant effect of Age Group, $F(1, 177) = 5.85$, $p = .02$, $\eta^2 = .03$. Older children ($M = 1.74$, $SD = 1.40$) were more accurate than younger children ($M = 1.29$, $SD = 1.09$). This was the only result that differed when Study was included in the analysis. There was a main effect of Study, $F(2, 173) = 3.64$, $p = .03$, $\eta^2_p = .03$, yet follow-up *t*-tests (Bonferroni corrected) demonstrated no significant differences. As we had no basis for predicting differences across studies, this result is not discussed further. Older and younger children's scores on this task were compared to chance (25%) in one-sample *t*-tests (alpha = .025) and found to be above, $ts \geq 2.51$, $ps \leq .014$, $ds \geq .26$. Here, chance was still considered to be one out of four (or 25%) because children's placement was unconstrained; that is, they could place the pictures and move them around until they were satisfied with their position.

Distance assessment

Using data from the distance assessment matrices, four 4 (Actual Day) × 4 (Linear Placement) chi-squares were computed, one for each of the age groups for the Temporal Position task and for the Serial Order task (see Tables 2 and 3 for the observed and expected values of children's placements). Results for the 4- to 5-year-olds [Temporal Position question: χ^2 (9, $N = 359$) = 36.74, $p < .001$, Cramer's $V = .18$; Serial Order question: χ^2 (9, $N = 353$) = 43.56, $p < .001$, Cramer's $V = .20$] demonstrated a primacy effect because children placed the instantiation that happened first in the first position more often than would be expected by chance. In contrast, for the remaining occurrences, little difference between observed and expected values was evident. In contrast to the younger children, the older children's temporal responses matched the actual day more than would be expected by chance for all instantiations, and they showed both primacy *and* recency effects [Temporal Position question: χ^2 (9, $N = 357$) = 88.62, $p < .001$, Cramer's $V = .29$; Serial Order question: χ^2 (9, $N = 360$) = 83.43, $p < .001$, Cramer's $V = .28$]. Older children rarely reported that the first instantiation happened the last time or that the last instantiation happened during the first occurrence.

DISCUSSION

A large body of research has shown that children's memories of repeated events differ in many ways from memories of events that have happened once. While children's memories of the content of repeated experiences may be quite good, they often confuse the temporal placement of specific content details. We investigated, for the first time, developmental differences in children's ability to judge the position and order of occurrences of a repeated event, and provided support for the scant literature on children's judgments of event frequency (e.g., Connolly, Hockley, & Pratt, 1996; Sharman et al., 2011). These data provide important new information about children's memories of the most common type of experiences, that is, ones that are repeated.

The results showed clear differences in temporal judgments as a function of age and event experience. By most measures, older children outperformed younger children, but inspection of the means reveals that the tasks were not simple for any of our children with repeated experience. As predicted, older children and those with a single experience

Table 2. Observed response frequencies for the Temporal Position question

Age	Actual day	Placement by child 1	2	3	4
4–5-year-olds	1	**42** (23.1)	9 (22.6)	19 (23.6)	22 (22.8)
	2	21 (22.3)	**25** (21.8)	21 (22.8)	22 (22.1)
	3	12 (22.1)	27 (21.6)	**24** (22.6)	25 (21.8)
	4	15 (22.6)	27 (22.1)	28 (23.1)	**20** (22.3)
6–8-year-olds	1	**46** (21.7)	16 (22.2)	19 (22.2)	6 (21.0)
	2	19 (22.2)	**32** (22.7)	26 (22.7)	12 (21.4)
	3	16 (22.2)	25 (22.7)	**26** (22.7)	22 (21.4)
	4	8 (22.9)	18 (23.5)	20 (23.5)	**46** (22.2)

Note: Bold numbers represent the correct response. Expected values in parentheses.

provided more accurate judgments of frequency than younger children and those with repeated experience. Also as hypothesized, the older children showed primacy and recency effects on the Temporal Position and Serial Order tasks (and to a lesser extent were correct for the second and third occurrences); the younger children did not show such a pattern for either the second, third, *or* last occurrence, but many accurately said that details from the first instance occurred first in the set (Tables 2 and 3). Finally, there was a developmental bias in the distance between the actual occurrence of an instantiation and children's temporal report of that instantiation, as others have also shown (Gosse & Roberts, 2013; Hudson & Mayhew, 2011).

Our data are consistent with the idea that younger children need more experiences than older children to build up a 'script' of the repeated event (Farrar & Goodman, 1992) and are also similar to Powell and colleagues' (2003) findings that children are more accurate at identifying the sequence of the first and last instantiations than they are at sequencing middle instantiations after participating in six similar, repeated events. It is plausible that it took four occurrences for the younger children to confirm 'what is similar' about the repeated events, and thus, they were not yet in the deployment phase to identify distinctive matter such as temporal information (e.g., Farrar & Goodman, 1992). Indeed, research on the *content* of children's memories for repeated experience has demonstrated that developmental differences are attenuated when considering children's reports for details that are the same or similar across occurrences (Brubacher, Glisic, et al., 2011; Powell et al., 1999). In contrast, age differences are evident for details with changing alternatives, in that younger children tend to confuse them across occurrences more than do older children, and it is the repetition of these changing details that is relevant to children's ability to particularize instances of abuse. It is still unclear which mechanisms account for children's confusions of details across temporal occurrences (e.g., immaturity of temporal metamemory; failure to monitor source effectively), and future research may want to consider carefully measuring these concepts as individual difference variables to assess their relationship, to each other and to the ability to reconstruct temporal placement of repeated events. In some recent work, children have been encouraged to compare memories of individual occurrences of repeated events and to note the differences between them (Brubacher, Glisic, et al., 2011; Brubacher et al. 2011). The assumption was that if children can remember the aspects that distinguish one instance from another, they can use such information to prevent confusion between instances. The results of these studies, however, have shown that while children can be supported in their retrieval of distinguishing features, they are still confused as to which instance those distinctive details came from.

Researchers have also explored the role of binding processes in children's source monitoring (e.g., Crawley et al., 2010). According to this approach, events are confused because distinctive details are not bound together with other useful source-specifying information like time. Successfully retrieving temporal information, then, can enhance retrieval of the context of the to-be-remembered instance and thereby allow successful distinction between sources. Similar to the data on temporal ability, there are clear developmental differences in the ease with which children can bind information together from one source (e.g., Crawley et al., 2010).

Table 3. Observed placement frequencies for the Serial Order question

Age	Actual day	Placement by child 1	2	3	4
4–5-year-olds	1	**43** (22.4)	12 (21.4)	15 (22.2)	18 (21.9)
	2	25 (22.9)	**25** (21.9)	21 (22.7)	19 (22.4)
	3	13 (21.9)	24 (21.0)	**24** (21.7)	25 (21.4)
	4	9 (22.7)	25 (21.7)	29 (22.4)	**26** (22.2)
6–8-year-olds	1	**49** (22.5)	20 (22.5)	13 (22.8)	8 (22.2)
	2	23 (23.5)	**34** (23.5)	20 (23.8)	17 (23.2)
	3	7 (21.5)	18 (21.5)	**31** (21.7)	30 (21.3)
	4	11 (22.5)	18 (22.5)	27 (22.8)	**34** (22.2)

Note: Frequencies in bold represent correct placements. Expected values in parentheses.

If young children are not able to extract abstract temporal information from experiences, then they will be disadvantaged at source monitoring (remembering which instance it was) because important temporal information cannot be used to determine source, and binding processes are limited. Prior to the current study, such a systematic analysis of the sorts of temporal information a large group of children of different ages and with varying event experience can remember has not been reported.

Developmental differences

The results showed significant developmental differences in all of the temporal tasks we administered. Specifically, the 6- to 8-year-olds were more accurate than the 4- to 5-year-olds at estimating the frequency of repeated occurrences, judging the relative order of instantiations from the Activities in comparison to the target occurrence, responding to questions about the temporal position of event details and sorting the serial position of instantiations from across the events. The current work provides an important characterization of developmental differences in memory for temporal information of repeated events but does not address whether the locus of these differences is at the encoding or retrieval phase. Namely, is younger children's poorer performance a result of a failure to confirm and deploy scripts during encoding, or an inability to use remembered content information and temporal metamemory to reconstruct the timing of details at retrieval? Both accounts are likely and are supported by the literature we presented, but future research could shorten the delay between the activities and the memory interview (or otherwise ensure very strong encoding at each occurrence) to shed more light on this question (we thank an anonymous reviewer for this suggestion).

The concept of time is an abstract one and, therefore, one that must be extracted from whatever information is available (e.g., we do not 'see' a week, but we consider a period of 7 days to form 'a week'). Such abstraction processes require a highly skilled representational system and are aided by knowledge of social conventions (e.g., Friedman et al., 2011); thus, even well-encoded details may continue to be confused across occurrences of repeated events. Many of the tasks in our battery used concrete materials to represent time, and some even allowed children to carry out temporal tasks without the added memory load. That is, in the Temporal Position and Serial Order tasks, pictures of instantiations from the occurrences were visible, in contrast to the Relative Order task, the latter being arguably more difficult for all of the children because the only scores above chance were from the older children for the first occurrence, and this result was only marginally significant. Indeed, other studies using concrete representations of time, such as the pictorial time line (Gosse & Roberts, 2013), demonstrate that children 5-years-old and older can benefit from visual aids, at least for events occurring within a day.

Children have particular difficulty with answering questions that are not presented in the same order as the events that occurred (e.g., it is more difficult to answer the question 'Before *you went to the Activities*, *did your mom tell you would participate*?' than to answer the question '*Did your mom tell you that you would participate* before *you went to the Activities*?'; Natsopoulos & Abadzi, 1986; see also Poole & Lamb, 1998). Thus, children's difficulty in answering the location question may have been because the format of the question regarding the first instantiation did not follow the actual order of events [i.e., Did the time (target occurrence) happen before or after the time you (instantiation from first occurrence)]. Yet, the only time children were (marginally) above chance in responding to the relative order question was for the older children responding to the question about the first instantiation. Children's difficulty with answering the relative question is therefore likely not only a matter of struggling with temporal terms and concepts but also due to the unique challenges posed by distinguishing among memories of repeated events. Indeed, while Hudson and Mayhew (2011) did not test children's memory for repeated events, they did find that 5- to 7-year-old children's semantic accuracy with temporal terms (e.g., 'two weeks ago' and 'last Friday') was *not* correlated with their ability to accurately locate the time of past autobiographical events. Taken together with the present findings, it is clear that even a developed understanding of temporal terms is not predictive of the ability to reconstruct the temporal source of memories in school-aged children.

Effects of event frequency

The children in the current study showed some impressive temporal skills if they had participated just once in the Activities. Almost all of the children (85%), including the 4- to 5-year-olds, accurately reported that they had taken part just one time. In sharp contrast, only 12% of the younger children and a third of the older children with repeated experience could accurately say that they had participated exactly four times (although they knew the events had happened more than one time). These results are consistent with Sharman and colleagues' (2011) findings that even after a 6-week delay, children as young as 4 years old can accurately report experiencing an event once and that all children (but especially younger children) who had experienced a similar event multiple times found it very difficult to provide a correct, specific estimate of how many times the event had occurred. These low accuracy rates suggest that while children retain some sense that experiences have happened on more than one occasion, they do not retain or reconstruct their memories to provide an exact report of event frequency. Similarly, Connolly and colleagues (1996) found that children's frequency estimates increased as the frequency of presentation of repeated information increased, indicating some implicit awareness of frequency. Taken together, these results support the use of questions asking children to judge whether events happened one time or more than one time during an investigative interview but not questions that require them to specify the number of repeated occurrences (e.g., 'how many times…').

Children with repeated experience also struggled to accurately sequence details from the specific experiences. Although chance analyses indicated that they were not simply guessing, on average, children correctly ordered fewer than half of the presented instantiations. Friedman and Lyon (2005), in apparent contrast, found that first-grade children were able to order two events. Children in the current study were asked to sequence *parts* of the events, rather than the events themselves, and they may have found it easier to correctly identify the first *event* as having occurred before the second *event* (as in Friedman & Lyon's 2005 study) than to identify the first *instantiation* of an item as having occurred before the second *instantiation* (e.g., the jellybean badge before the button badge; as in the current study). This proposition needs further investigation, but at the very least, we now know that the ordering details from different instances of a repeated event is not likely to be a reliable way of eliciting the sequence of events from children 8 years old and younger. Additionally, the present research used four rather than two occurrences, and the occurrences were all very similar to each other, in contrast to Friedman and Lyon's (2005) events. Thus, the children here were more likely to be confused between individual episodes (Hudson, Fivush & Kuebli, 1992; see Roberts, 2002).

CONCLUSIONS

The current research makes a novel and important contribution to our understanding of children's temporal memory. By using a very large database, the increased difficulty of temporally sequencing individual instances of a *repeated* event (compared with one-time events) was clearly and reliably demonstrated. Overall, these results suggest that the legal requirement regarding the precision with which children answer questions about the time of alleged events may not be reasonable, a finding consistent with previous research (e.g., Friedman & Lyon, 2005; Friedman et al., 2011). Guadagno and Powell (2009) found that 65% of children alleging abuse in their Australian sample were asked to indicate the number of occurrences. In the current study, children were able to indicate that an event happened just once, but were generally incorrect when attempting to give the precise number of repeated occurrences, and these results were present after only a short delay (1 week), whereas children in the legal system are often interviewed after much longer delays. Nonetheless, although some temporal judgments are difficult for children, they are able to remember what did actually happen during the events (e.g., Hudson & Nelson, 1986; Pearse, Powell, & Thomson, 2003), and we have shown here that they can provide at least some important and useful temporal information. Children with repeated-event experience were aware that the event had taken place more than one time and were able to accurately provide other important temporal information, such as which details happened first across the series of events.

Witnesses, including children, are asked to provide information about the timing and frequency of alleged instances for reasons including the opportunity of the defendant to provide an alibi and the determination of appropriate charge(s) so that individual jurors consider the same offence(s) when reasoning about verdict rather than making their decisions based on a defendant's general propensity to commit (or not) a particular crime (Powell et al., 2007; *S. v. R.*, 1989). The current data demonstrate, however, that these needs are at odds with the developmental capabilities of young children who have been exposed to repeated events. Instead, (i) specific frequency questions posed to children 8-years-old and younger in investigations and court should be avoided because they are likely to yield little informative information (although children will be able to accurately indicate if an event was repeated or not), and (ii) a failure to provide exact frequency information should not be used as a reason to consider the entire testimony as unreliable, because actual details are well remembered after repeated, similar experiences.

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APPENDIX A

Sample list of all items that could be included in the activities and their possible instantiations

Item (activity)	Set A	Set B	Set C	Set D
Children sit on	Number square	Blue mat	Garbage bag	Cardboard
Cloak leader wears	Red	Yellow	Blue	Green
Noisy animal visits	Polar Bear	Penguin	Walrus	Seal
Warm-up activity	Wiggle fingers	Touch toes	jump	Dance
Source of story	Leader wrote	Cupboard	Internet	Library
Content of story	Dog in City	Winter	Party	Boat
Bookmark	Pink heart	Black triangles	Orange circles	Purple squares
Clown puzzle	Tightrope	Unicycle	Juggling	Car
Music for relaxing	Ocean	Rain	Birds	Heartbeat
Body part relaxed	Legs	Nose	Stomach	Arms
Refresh with	Paper fans	Baby wipes	Water	Hand sanitizer
Theme of magnet picture	Airport	Dinosaur	Farm	Construction
Pick magnets from a	Box	Purse	Envelope	Jar
Objects hidden	Flowers	Frogs	Cars	Tambourines
Objects hidden under	Blanket	Umbrella	Pillow Case	T-shirt
Put objects away in	Hat	Cookie tin	Lunchbox	Egg Carton
Leader's next stop	Movie	Walking a dog	Birthday party	Visit friend
Badge	Button	Leaf	Feather	Jellybean

