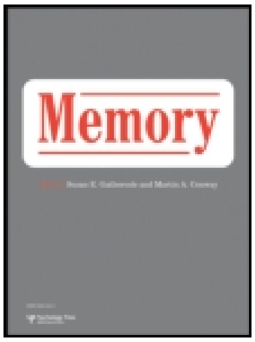

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A "snapshot" of declarative memory: Differing developmental trajectories in episodic and autobiographical memory

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Episodic and autobiographical memory are clearly related, yet in both the adult and developmental literatures it is difficult to compare them because of differences in how the constructs are assessed, including differences in content, levels of control, and time since experience. To address these issues, we directly compared children's and adults' autobiographical and episodic memory using the same controlled paradigm. Participants engaged in a photo-taking activity in a museum (autobiographical encoding) and viewed others' photographs of the same museum exhibits (episodic encoding). At test, participants classified photos as ones they took, viewed, or novel. In the autobiographical condition older children and adults performed similarly; younger children's performance was lower than adults'. In contrast, in the episodic condition both groups of children performed more poorly than adults. The findings suggest the developmental primacy of autobiographical relative to episodic memory, and that traditional episodic tasks may underestimate older children's declarative memory abilities.

Keywords: Autobiographical memory; Episodic memory; Memory development.

The capacity to remember past events is fundamental. From significant events like weddings and graduations, to more mundane events, like where the car was parked this morning, the capacity to remember is a central part of our lives. This type of memory is episodic—it is for events tied to a particular place and time (Tulving, 1984). Memories of events such as weddings and graduations in particular, also may be characterised as autobiographical because they are personally relevant. Although episodic and autobiographical memory are clearly closely related, they are typically studied separately (see Gilboa, 2004; McDermott, Szpunar, & Christ, 2009). As a result, relations between them, and their respective developmental trajectories, are not well understood. The goal of the present research was to address these issues by bringing the literatures into closer alignment with a paradigm that allowed for test of recognition of both autobiographical and episodic memory in both adults and children.

The relation between episodic and autobiographical memory is a matter of debate (see Gilboa,

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2004). Some conceptualise episodic and autobiographical memory as synonymous, both supporting recollection of personally experienced events and their contexts (e.g., Gardiner, 2001; Kopelman & Kapur, 2001; Tulving, 1972). Others view autobiographical memory as a distinct type or subtype of episodic memory, specialised for personally relevant events (e.g., Wheeler, Stuss, & Tulving, 1997). Episodic and autobiographical memory are also distinguished on a temporal dimension, operating on short and longer time scales, respectively (Conway, 2001; Conway & Pleydell-Pearce, 2000). Yet another view is that autobiographical memory is a mixture of episodic and semantic memory (see Cabeza & St. Jacques, 2007). Disagreements about the constructs also pervade the developmental literature in which the major issue is whether autobiographical memory makes a relatively early (e.g., Howe & Courage, 1993) or late (e.g., Perner, 2000) appearance in childhood. Yet these differences too stem from differing conceptualisations of the relation between episodic and autobiographical memory (for discussion see Bauer, 2007).

In spite of these controversies, progress has been made in understanding both autobiographical and episodic memory in both adults and in development. By and large, however, the four literatures do not inform one another. In both the adult and developmental literatures, methodological differences make comparison of findings from studies of episodic and autobiographical memory difficult at best. Typically, examinations of episodic memory involve assessments of the accuracy of recall or recognition of words, pictures, or other controlled stimuli over relatively short delays (e.g., Eldridge, Knowlton, Furmanski, Bookheimer, & Engel, 2000; Henson, Rugg, Shallice, & Dolan, 2000; Ofen et al., 2007). In contrast, autobiographical memory is tested by asking children (e.g., Bauer, Burch, Scholin, & Güler, 2007; Fivush, Gray, & Fromhoff, 1987) or adults (e.g., Rubin, Wetzler, & Nebes, 1986) to recall events from their daily lives. Encoding cannot be controlled, accuracy is difficult to assess, and the delay between experience and test may be months or years. The different methodologies make it hazardous to compare findings from studies of episodic and autobiographical memory (see McDermott et al., 2009).

A paradigm introduced in the adult literature allows for direct comparison between episodic and autobiographical memory retrieval. In Cabeza et al. (2004), adults photographed specified locations around a university campus over a 10-day period. They were instructed,when taking each photo, to mentally note physical (e.g., lighting, temperature) and psychological (e.g., mood) aspects, thus making the photo-taking experience more personally relevant. Days later they viewed and rated the aesthetic quality of photographs taken by others of the same locations. At retrieval, participants decided whether photos were ones they took (autobiographical encoding condition), photos that they saw and rated (episodic encoding condition), or novel photos. Analysis of corrected recognition scores (hits minus false alarms) in each condition revealed no differences in performance. However, condition differences were apparent in neural activations as measured by functional magnetic resonance imaging (fMRI). Specifically, in both conditions there were activations in the medial temporal lobe and prefrontal cortex. In addition, in the autobiographical encoding condition there was greater activity in medial prefrontal cortex, visual and parahippocampal areas, and hippocampus, areas implicated in self-referential processing, visual or spatial memory, and recollection, respectively.

In the present research we adapted the paradigm introduced by Cabeza et al. (2004) to allow direct comparison of behavioural recognition of episodic and autobiographical memory in adults and developing children. Bringing the adult and developmental literatures into direct contact is beneficial for two reasons. First, examining the developmental trajectories of these two types of memory can inform the relations between them. For instance, differing developmental trajectories would suggest theoretically significant differences between the constructs. Second, description of the developmental time course is not complete without comparison to adult performance. There are some direct comparisons of performance by children and adults on episodic memory tasks in which the same stimuli (e.g., line drawings) are appropriate for children and adults (e.g., Cycowicz, Friedman, Snodgrass, & Duff, 2001). There are virtually no opportunities to directly compare children and adults in autobiographical memory tasks, because the events in which children and adults engage are so different. Bringing the literatures into closer alignment thus stands to inform both.

We focused the research on two groups of school-age children (7- to 9-year-olds and 9- to 11-year-olds) and adults. School-age children were selected both because they were expected to be able to participate in the protocol and because they are a relatively understudied age group. Several studies have examined recall of specific past events in preschool-age children (e.g., Fivush et al., 1987; Hamond & Fivush, 1991; for reviews see Bauer, 2007; Nelson & Fivush, 2004). In contrast, there is little research on memory for personal events beyond the preschool years. As reviewed in Bauer et al. (2007), only a handful of studies (e.g., Fivush & Schwarzmueller, 1998; Sheingold & Tenney, 1982; Van Abbema & Bauer, 2005) have examined autobiographical memory in older school-aged children. The primary focus of the studies has been older children's recall of events experienced years earlier. As a result, we know little about changes in autobiographical memory beyond the preschool years. By directly comparing two groups of children and adults we can make important progress in understanding the developmental trajectories of both episodic and autobiographical memory.

To permit direct comparisons of memory under episodic and autobiographical encoding conditions and direct comparisons of children and adults, 7- to 9-year-olds, 9- to 11-year-olds and adults visited a museum and took photographs of exhibits. As in Cabeza et al. (2004), they were instructed to remember each photo-taking event and mentally note the physical features of the objects being photographed, lighting conditions, and how they felt about what they were photographing. The instructions created encoding conditions akin to those for autobiographical memory (autobiographical encoding). Participants then viewed and judged the quality of photographs of museum exhibits taken by someone else, tasks akin to those used in tests of episodic memory (episodic encoding). Later, participants decided whether photographs were ones they took themselves, photographs they viewed, or novel photographs.

Overall, we expected adults to perform more accurately than children. Based on the behavioural results of Cabeza et al. (2004), we expected adults to have comparable performance in the autobiographical and episodic encoding conditions. For children, expectations regarding relative levels of performance in the autobiographical and episodic encoding conditions were less obvious. One could reasonably argue that performance in the autobiographical encoding condition would be higher than in the episodic encoding condition, based on the assumption that increased self-involvement and reflection on the photograph taking experience would allow for more robust encoding and efficient retrieval. Alternatively it is equally logical to predict that performance in the autobiographical encoding condition would be lower than in the episodic encoding condition, given that several of the conceptual domains associated with autobiographical memory undergo protracted development (e.g., self concept, understanding of temporal dimensions, source memory; e.g., Bauer, 2007; Nelson & Fivush, 2004). The third possibility—comparable levels of performance in the two conditions—could reasonably be expected as well, based on the pattern observed among adults in Cabaza et al.

METHOD

Participants

A total of 17 children 7–9 years old (10 girls; $M = 7.70$, range = 7.17–8.83), 18 9- to 11-year-olds (6 girls; $M = 10.37$, range = 9.25–11.83), and 20 adults (15 women; $M = 20.12$, range = 18.50–26.75) participated. Children were recruited from a volunteer pool; adults were recruited from an undergraduate student subject pool. Of these participants, 80% were Caucasians. One additional child was excluded because of computer malfunction. Adults gave informed consent to participate; parents gave consent for their children and children gave assent. The protocol was approved by the university Institutional Review Board. Children received a toy and $10 gift certificate; adults received course credit.

Stimuli

Stimuli were photographs of objects and exhibits at the Fernbank Museum of Natural History, Atlanta, Georgia. Constraints were that the subjects of the photographs were (a) indoors, (b) not behind highly reflective surfaces, and (c) stationary. For the episodic and autobiographical encoding conditions, an additional constraint was that the subjects of the photographs were in permanent museum collections. Within these constraints, for use in the episodic encoding condition, we photographed 10 objects in each of six categories: (a) fish and shells, (b) dinosaurs or fossils, (c) contemporary animals, (d) characters, (e) signs, and

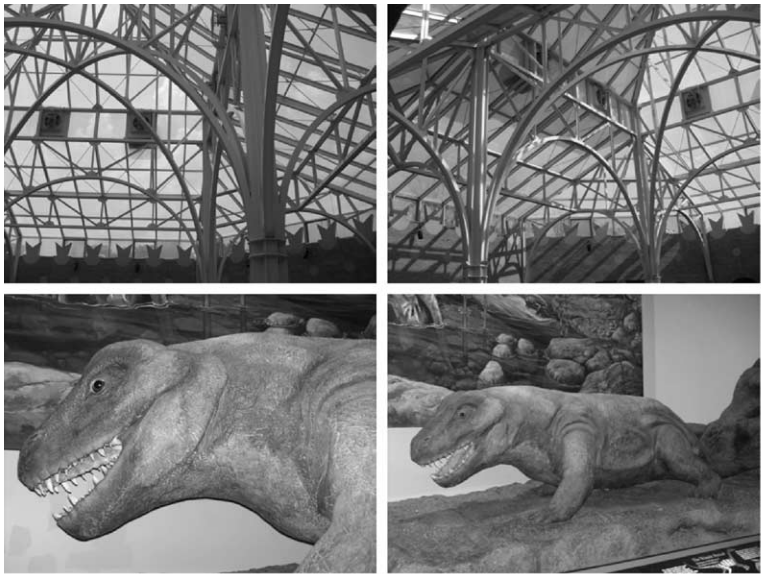

Figure 1. Photographs taken by participants during autobiographical encoding. Example photographs were taken by 7-year-olds (photos on left) and adults (photos on right) for a specified location in the ''architectural features'' category (top) and ''dinosaurs or fossils'' category (bottom). Photographs shown here converted from colour to greyscale for publication.

(f) architectural features. For the novel photograph set we took an additional 30 photographs of exhibits or objects that participants would not view. All photographs were taken using the same camera and settings participants would use. The stimuli for the autobiographical encoding condition were taken by the participants themselves (see Procedure). Example photographs are provided in Figure 1.

Procedure

Following the procedure in Cabeza et al. (2004), the study involved three sequential parts: autobiographical event encoding, episodic event encoding, and test for recognition. To make the paradigm child-friendly some procedural departures from Cabeza et al. were made. First, in Cabeza et al. photographs were taken over 10 days and episodic encoding occurred 1–3 days later. In the present study all photographs were taken and viewed in one day because (a) it would be unreasonable to ask participants to visit the museum location over a 10-day period, and (b) it reduced the likelihood that participants would use familiarity or recency as a basis for distinguishing photographs encoded in the autobiographical and episodic conditions (thus eliminating a potential confound in Cabeza et al.). In addition we chose a museum as the site (versus a university campus) to equalise familiarity of the location for the two groups. Finally, whereas in Cabeza et al. the novel items were unfamiliar photographs of familiar locations, in the present study the novel photographs were of novel locations in the museum.

At the first session participants met one of six experimenters at the museum. Following a script, the experimenters explained to the participant that s/he would be taking photographs and that s/he should try to remember them because they would later be tested on their memory for the photographs they took (verbatim instructions are available from the first and last authors). The experimenter then described how to operate the digital camera. Participants were instructed (a) not to use the zoom functions, but instead to physically move closer or further away from the object to obtain the effect they desired; (b) to take only horizontal (landscape-format) photographs; and (c) to avoid photographing people. These restrictions were imposed to increase participants' engagement in the picture-taking event, to ensure consistency among photographs, and to avoid cues as to the source of the photograph (e.g., a family members in a photograph would signal that it was taken by the participant), respectively.

Autobiographical encoding condition. Experimenters accompanied participants throughout the museum and made certain they did not review the photographs through the viewfinder after they were taken. Participants were instructed to place themselves in the picture-taking event by thinking about how they felt about each object or exhibit, how they would photograph the object or exhibit, the lighting conditions, and so forth. Participants photographed 30 objects or exhibits specified by the experimenter (specified condition) and 30 objects or exhibits of their choice (choice condition). In each condition the photographs were of five objects or exhibits from each of the six categories listed above. An additional constraint on the *choice* photographs was that they could not be the same subjects photographed in the *specified* condition. The choice manipulation was intended to further increase the autobiographical nature of the picture-taking event by allowing personal selection of subject matter. However, the manipulation did not affect performance in the autobiographical condition and thus will not be discussed further (analyses are available from the first and last authors). Participants took three photographs of each object or exhibit to ensure an optimal photo for test (see below; e.g., not obscured by the participant's finger; non-optimal photographs were rare). All participants took the photographs in the same order.

Episodic encoding condition. After taking the photographs in the autobiographical encoding condition, participants sat at a table in a quiet area of the museum and on a laptop computer viewed 60 photographs of museum exhibits that had been taken by someone else; photographs were viewed in the same random order by all participants. Each photo remained on the screen for 10 seconds (as in Cabeza et al., 2004). The exposure duration approximated the time required to take three photographs of each object/exhibit in the autobiographical encoding condition. As in Cabeza et al., participants rated each photograph's aesthetic quality. We used a 3-point (1 = "bad picture"; 3 = "really good picture") rather than a 5-point, Likert-type scale to accommodate children. Participants were explicitly told that they would later be tested on their memory of the photographs they viewed.

Recognition test[1]. One to two days later ($M = 1.4$ days), participants visited the laboratory and viewed the 60 photographs they had taken, the 60 photographs viewed on the laptop, and 30 novel photographs. Participants viewed photographs in the same pseudo-random order with the constraint that no more than three photographs of the same trial type occurred in a row. Each photograph was presented for 6 seconds with a 3-second black-screen ITI. Participants pressed different buttons for photographs they "remember taking", "viewed on the laptop", and "were new". To promote accuracy and encourage attention towards the recollective experience, the instructions emphasised accuracy over speed (as in Cabeza et al., 2004).

RESULTS

To accommodate the two types of "old" stimuli we adapted the traditional classification of hits, false alarms, misses, and correct rejections. As reflected in Table 1 (Panel a), *autobiographical hits* (H_A) were photographs correctly classified as taken by the participant; *episodic hits* (H_E) were photographs correctly classified as having been seen on the laptop; *correct rejections* (CR_N) were photographs correctly classified as novel. Two types of *false alarms* were possible: incorrect classification of a novel photograph as autobiographical (FA_{N*A}) or episodic (FA_{N*E}). Two types of *misses* also were possible: incorrect classification of an autobiographical or episodic photo as novel (M_{A*N} or M_{E*N}, respectively). Further, participants could make two types of encoding condition errors or *source slips*: classify a photo that they took as one that they saw on the laptop (SS_{A*E}), or vice versa (SS_{E*A}). Observed means and standard deviations are in Table 1

[1]Of the 35 children, 15 participated in an ERP (event-related potential) procedure during the recognition test. In addition, during encoding of the episodic encoding condition these participants were asked to rate how a professional photographer would rate the photograph instead of how the participant her/himself would rate the photograph. The results reported do not differ when this subgroup of children is analysed separately (details are available from the first and last authors). Thus the different procedures will not be discussed further.

TABLE 1
Response classifications and descriptive statistics of performance in each age group

Response classifications			*Trial*		
			Old		*New*
Panel a			Autobiographical	Episodic	
Participant response	Old	Autobiographical	*Hit* (H_A)	*Source slip* (SS_{E*A})	*False Alarm* (FA_{N*A})
		Episodic	*Source slip* (SS_{A*E})	*Hit* (H_E)	*False Alarm* (FA_{N*E})
	New	Novel	*Miss* (M_{A*N})	*Miss* (M_{E*N})	*Correct Rejection* (CR_N)
			Trial		
			Old		*New*
Panel b			Autobiographical	Episodic	
Younger children ($N = 17$)					
Participant response	Old	Autobiographical	.773 (.08)	.248 (.14)	.039 (.07)
		Episodic	.074 (.04)	.427 (.23)	.071 (.08)
	New	Novel	.121 (.10)	.283 (.19)	.841 (.17)
Older children ($N = 18$)					
Participant response	Old	Autobiographical	.789 (.10)	.205 (.09)	.013 (.03)
		Episodic	.104 (.06)	.619 (.15)	.117 (.16)
	New	Novel	.087 (.09)	.163 (.12)	.856 (.16)
Adults ($N = 20$)					
Participant response	Old	Autobiographical	.870 (.13)	.127 (.08)	.003 (.01)
		Episodic	.073 (.07)	.740 (.14)	.028 (.06)
	New	Novel	.032 (.03)	.133 (.13)	.968 (.08)

(Panel b). Because there were no significant effects associated with the length of the delay between encoding and the recognition test (range 1–2 days), the values reflect the means regardless of delay.

Corrected recognition scores were calculated by subtracting the proportion of false alarms from the proportion of hits (as in Cabeza et al., 2004) for the autobiographical (H_A minus FA_{N*A}) and episodic (H_E minus FA_{N*E}) conditions. The group means (and standard deviations) of corrected recognition scores for younger children, older children, and adults were .733 (.117), .776 (.115), and .867 (.131), respectively, in the autobiographical encoding condition; and .357 (.266), .502 (.193), and .712 (.148), respectively, in the episodic encoding condition (Figure 2). A 3 (age: younger children, older children, adults) × 2 (condition: autobiographical, episodic) mixed analysis of variance (condition is within-participants) revealed main effects of Age, $F(2, 52) = 14.31$, $p < .0001$, $\eta^2 = .18$, and Condition, $F(1, 52) = 114.88$, $p < .0001$, $\eta^2 = .31$. Tukey's Studentised Range Tests revealed that, overall, adults' corrected recognition scores were higher than both younger and older children's scores, and overall, scores in the autobiographical condition were higher than in the episodic condition.

These main effects were qualified by an Age Group × Condition interaction, $F(2, 52) = 6.62$, $p < .003$, $\eta^2 = .04$. Analysis of this interaction revealed that for all three age groups, performance in the autobiographical encoding condition was greater than in the episodic encoding condition. The source of the interaction was revealed in analyses by condition. There were age group differences in both the autobiographical and episodic encoding conditions: $F(2, 52) = 5.86$, $p < .006$, $\eta^2 = .18$, and $F(2, 52) = 14.16$, $p < .0001$, $\eta^2 = .35$, respectively. Follow-up Tukey tests revealed that in the autobiographical encoding condition, adults' scores were higher than younger children's scores; there was no difference between scores of older children and adults or older children and younger children. In the episodic encoding condition adults' scores were higher than *both* groups of children; there was no difference between the scores of the younger and older children. Thus different developmental trajectories were apparent for recognition performance in the autobiographical and episodic encoding conditions (Figure 2). It is unlikely that ceiling effects can explain the different developmental trajectories for each encoding task. Although performance in the autobiographical condition was high, the older child group was not at ceiling yet exhibited different relative

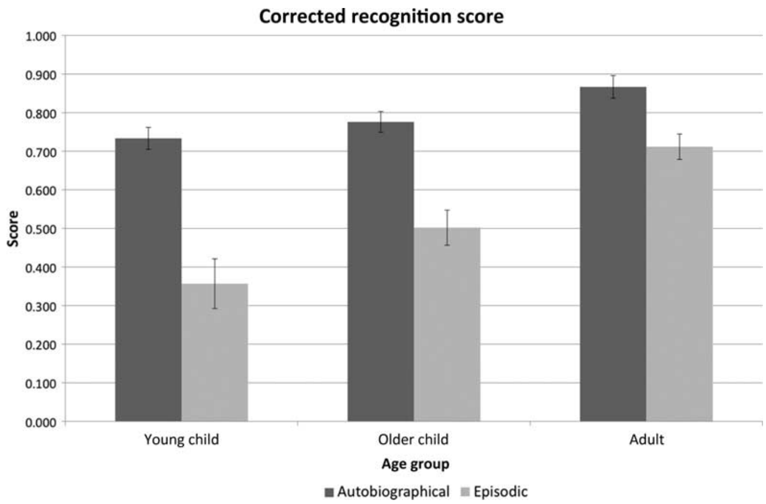

Figure 2. Corrected recognition score for each condition and age group. Corrected recognition score is equal to hits minus false alarms for each condition.

patterns of performance as a function of encoding condition.

Next we examined the proportion of *source slips* in the autobiographical and episodic encoding conditions. Source slips are errors in which the participant correctly classified a photograph as old, but misattributed the encoding condition associated with the photograph. Levels of performance for each age group and condition are depicted in Figure 3. Consistent with the analyses of corrected recognition scores, there were suggestions of the primacy of development of autobiographical relative to episodic memory. Specifically, a 3 (age: younger children, older children, adults) × 2 (condition: autobiographical, episodic) mixed analysis of variance revealed main effects of Age, $F(2, 52) = 4.65$, $p < .02$, $\eta^2 = .07$, and Condition, $F(1, 52) = 54.46$, $p < .0001$, $\eta^2 = .26$, which were qualified by their interaction, $F(2, 52) = 5.64$, $p < .007$, $\eta^2 = .05$. Overall, adults made fewer source slips than both groups of children, and fewer source slips were made in the autobiographical than the episodic condition. To examine the interaction we conducted separate ANOVAs for each encoding condition. In the episodic encoding condition, relative to adults, younger children more often erroneously identified a photograph taken by another as one they had taken themselves (see Figure 3), $F(2, 52) = 6.14$, $p < .005$, $\eta^2 = .19$ (Tukey's Studentised HSD used as follow-up). The number of source slips did not differ between

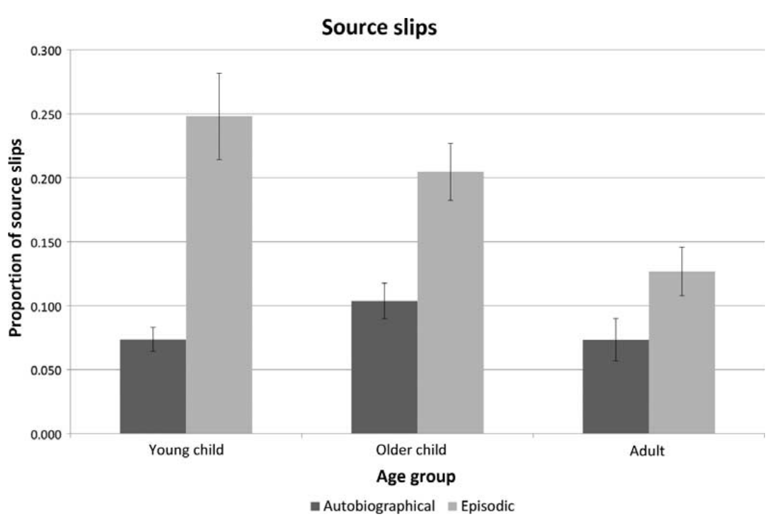

Figure 3. Source slips for each condition and age group.

younger children and older children, or between older children and adults. In contrast, in the autobiographical encoding condition there was no effect of age ($F = 1.54$, $p = .23$). In other words, children were no more likely than adults to erroneously classify a photograph they had taken as one that they had seen on the laptop.

DISCUSSION

In the present research we compared performance by two groups of school-aged children and adults in the same controlled paradigm, under episodic and autobiographical encoding conditions. To our knowledge this is the first such study in the literature. We delineated differing developmental trajectories in each encoding condition. As assessed in this paradigm, younger children (7- to 9-year-olds) did not show adult-like performance in either autobiographical or episodic memory. In contrast, older (9- to 11-year-old) children's performance was adult-like for autobiographical but not episodic memory.

These results have several implications for both the adult and developmental memory literatures. First, the finding that 9- to 11-year-old children and adults performed similarly in the autobiographical encoding condition suggests that traditional episodic memory paradigms may underestimate older children's memory abilities. Second, the fact that older children's recognition accuracy was similar to adults in the autobiographical encoding condition, but not the episodic encoding condition, suggests that autobiographical memory has primacy in development relative to episodic memory. Primacy may result from the greater self-relevance or self-reflective nature of autobiographical events, rendering them more meaningful and consequently, more memorable. However, this contradicts a common view in the developmental literature that autobiographical memory is later-developing, because many of the cognitive abilities on which it depends (e.g., self, concepts of time) are themselves later to develop (see Nelson & Fivush, 2004). Third, the differing developmental trajectories of performance in autobiographical and episodic encoding conditions reported in the present study suggest theoretically significant differences between autobiographical and episodic memory tasks and constructs.

The present study suggests different developmental trajectories for episodic and autobiographical memory, and that autobiographical memory may outpace its less personally relevant episodic counterpart. Yet the work provides only a "snapshot" into the development of declarative memory. Additional work is needed to determine whether there truly are dissociable developmental trajectories, and the precise relations between them. Alternatively, it is possible that the "snapshot" reflects differences in the strength of the representations assessed in the episodic and autobiographical conditions. Neuroimaging data from the earlier analogue of this paradigm indicated that autobiographical encoding engaged more self-referential processing and visual/spatial memory than episodic encoding (see Cabeza et al., 2004). This might have resulted in quantitatively "richer" memory representations on which participants could draw, thus supporting similar performance by older children and adults. Older children might have performed more poorly than adults in the episodic encoding condition because their less mature memory systems could not compensate for the "poorer" (i.e., weaker) memory representations. Further research is necessary to differentiate between these possibilities. The paradigm used in this research is ideally suited to the task because it would permit manipulations of the parameters of support in each encoding condition (e.g., more encoding time, deeper processing, etc.).

Despite the fact that autobiographical recognition memory in older school-aged children resembled that of adults, we reported ways in which, overall, children's memory performance was poorer than adults. Compared to children, when adults remembered an event as "old" they more often matched the event to its corresponding encoding condition. This finding is consistent with work done on source memory using traditional episodic tasks in which children have difficulty determining the source of studied items (e.g., Cycowicz et al., 2001). Yet the situations are different. In studies on source memory participants are typically required to provide a specific type of spatial, temporal, or social contextual information from the encoding experience (see Johnson, Hashtroudi & Lindsay, 1993). For example, at retrieval participants may be asked to judge the colour of ink in which a word was presented at study, or judge whether a female or male voice read a sentence at study. In the present investigation, however, participants were not required to make judgements about one particular type of contextual information associated with an event. Instead, multiple contextual cues were available for participants to retrieve in order to reconstruct the encoding experience. Thus, although the findings of the present research are consistent with findings on the development of memory for source, the questions are different.

The results of the present study are also consistent with the self-reference effect reported in the adult cognitive psychology literature. In self-reference effect, studied items that are judged in relation to the self (e.g., ''does this word describe you?'') are remembered better than studied items judged in relation to another person (e.g., ''does this word describe person X?'') or are remembered better than items processed semantically (for review see Symons & Johnson, 1997). This effect is similar to our findings in which, across age groups, photographs that were encoded with increased self-involvement (participant asked to take the photograph, and think about how s/he feels about the photographed exhibit etc.) were remembered better than photographs that participants viewed on a computer and judged for aesthetic quality (less self-referential processing). At the same time, this finding may be related to a phenomenon termed the generation effect (Slamecka & Graf, 1978): adults better recall or recognise words that they generated themselves (e.g., antonyms) compared to words that they read. In the present study, stimuli generated by the participant were their own photographs. It is possible that some of the same mechanisms that help to enhance memory for self-generated words and sentences in studies of the generation effect also help to enhance memory for other self-generated stimuli such as photographs.

Observations of differences in performance by adults and school-age children may seem curious in light of abundant evidence that even preschoolers recall past events. Yet preschoolers' recall is but an early step along the long road of development of episodic and autobiographical memory (e.g., Bauer, 2007). An important rate-limiting variable in development is the neural substrate that supports these memory functions. Well into adolescence there are gradual increases in hippocampal volume (Gogtay et al., 2004; Pfluger et al., 1999) and myelination in the hippocampal region (Arnold & Trojanowski, 1996; Schneider, Il'yasov, Hennig & Martin, 2004). In prefrontal cortex, throughout adolescence there are changes in the number of synapses (Huttenlocher, 1979), in grey matter volume, and in myelination and connectivity between brain regions (Johnson, 1997; Klingberg, Vaidya, Gabrielli, Soseley, & Hedehus, 1999; Schneider et al., 2004). The connections between hippocampus and frontal structures are not fully forged until late in development (e.g., Fuster 2002). The protracted development of the neural structures and networks known to be involved in episodic and autobiographical memory no doubt has functional consequences (e.g., Ofen et al., 2007). It may help explain why the younger school-aged children tested in the present research differed from adults in our assessments of both autobiographical and episodic memory, and why within childhood there were age-related differences in performance. These findings highlight the importance of comparisons not only of levels of performance of children of different ages, but also of children with adults.

Continued progress in understanding episodic and autobiographical memory, the relations between them, and their respective developmental trajectories, will be aided by address of two limitations of the present research. The first is that although taking a photograph may be more self-relevant and ''autobiographical'' than viewing a photograph taken by another, it is not as personally meaningful as many of the events that make up our autobiographies. Moreover, several features of autobiographical memory (e.g., emotion, vividness; see Cabeza & St. Jacques, 2007) were minimal or absent in this paradigm. Even as some conceptually significant differences between autobiographical and episodic encoding conditions were minimised in the present research, other potentially confounding differences between the conditions were present. In the autobiographical condition encoding of items involved (a) active participation in the environment, (b) transitions between rooms and contexts, and (c) temporal spacing between events. In contrast, in the episodic encoding condition, encoding of items involved (a) viewing on a computer screen, (b) sitting in one location, and (c) minimal spacing between events. On the one hand, some or all of these differences may be found to explain significant variance in performance in the different conditions. On the other hand, that is precisely the point: episodes that become autobiographical are encoded differently from episodes that do not. Nevertheless, in future research it would be desirable to vary each of these factors and isolate those that contribute to differential patterns of memory such as reported here.

The second limitation of the present research is that participants received explicit instructions to remember, and the task orders were the same for all participants. How the instructions impacted performance, and whether adults and children used different strategies to remember, cannot be assessed in the present research. Nor can the effects of the fixed order of experience be assessed. These conditions must be taken into account in evaluating the present research, and their impact should be examined in future research.

In conclusion, we directly compared children and adults in two mnemonic domains (autobiographical and episodic memory) using the same controlled paradigm, with the result that four separate literatures were brought into closer alignment. The work not only provides a rare "snapshot" of the relative levels of development of episodic and autobiographical memory, but also lays the groundwork for further research with a productive paradigm. For example, more fine-grained analysis of age-related changes throughout childhood could fruitfully be examined, especially given the evidence reported here that older school-aged children differ from younger school-aged children in recognition of the context of encoding. Future work may focus on the development of the underlying neural substrates involved in declarative memory. As noted by Cycowicz (2000), neuroimaging methods, like event-related potentials (ERP), are beneficial because they can be used across the lifespan. The paradigm used in this investigation could easily be combined with neuroimaging to study the development of the underlying neural substrates and processes involved in autobiographical and episodic memory.

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