The Influence of Time Knowledge and Retrieval Strategies on Temporal Memory in Middle and Late Childhood

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Introduction

Episodic memory—memory for events from a specific time and place—allows us to mentally travel through time and to relive our past experiences (Tulving, 1972, 2002). Time is a critical feature of episodic memory, and the events of our lives are inherently organized by *when* they occurred (Friedman, 1993). Previous research indicates that temporal memory is slower to develop than other episodic memory features (e.g., 'what' and 'where; Lee et al., 2016), and improvements are observed across middle and late childhood (Friedman & Lyon, 2005; Pathman & Ghetti, 2014; Pathman, Larkina, Burch, & Bauer, 2013; Reese et al., 2011). However, the factors responsible for this more protracted development of temporal memory are not yet clear. Previous research has examined the following aspects of temporal memory:

Temporal order: order events in relation to each other (e.g., X happened before Y)
- Memory for temporal order emerges during the first two years (see Bauer, 2007, for review), and continues to develop across childhood and into adulthood (Pathman & Ghetti, 2014)

Temporal context: placing events in time
- Arbitrary time scales (e.g., List 1, List 2)
- Conventional time scales (e.g., days of week, months of year)
- Children's ability to place events on conventional time scales improves across early and middle childhood, and by late childhood this ability becomes more adult-like (Friedman, 1991; Pathman et al., 2013).
- Events that are rich with context might be easier to place on conventional time scales, especially given children's growing understanding of time during these periods (Friedman, 1978).
- The use of arbitrary events and time scales can help to narrow down the processes or strategies involved in the development of memory for temporal context.

Distance-based strategies: judging when an event occurred based on how clear or vivid the memory is compared to other event memories (i.e., more vivid = more recent; Friedman, 1993, 2014)

Reconstruction strategies: recalling event details and combining them with knowledge of time in order to make a temporal judgment (Friedman, 1993, 2014) From early to late childhood, there is evidence that children's ability to use reconstruction improves (Friedman, 1991; Friedman & Lyon, 2005; Pathman et al., 2013)

Conventional time: systems and representations of cultural patterns that a culture uses (e.g., days of the week, months of year)
- From middle to late childhood, children improve in their ability to understand conventional time patterns (e.g., ordering the months of the year; Friedman, 1978)
- Researchers have found a relation between a conventional time knowledge (CTK) task and the ability to place past events on time scales during middle and late childhood (Friedman, Reese, & Dai, 2011; Pathman & Ghetti, 2014)

Goals of current study:
- Track the development of memory for temporal context during middle and late childhood and adulthood with a recognition memory paradigm
- Examine the use of retrieval strategies children and adults use to place events in time
- Investigate how time knowledge influences memory for temporal context across development

References

Bauer, P.J. (2007). *Remembering the times of our lives: Memory in infancy and beyond*. Mawah, NJ: Lawrence Erlbaum Associates.
Curran, T., & Friedman, W. J. (2003). Differentiating location- and distance-based processes in memory for time: An ERP study. *Psychonomic Bulletin & Review, 10*(3), 711-717. doi: 10.3758/bf03196536
Friedman, W. J., (1978). Development of time concepts in children. In H. W. Reese & L. P. Lipsitt (Eds.), *Advances in child development and behavior* (pp. 267-298). New York, NY: Academic Press. doi: 10.1016/s0065-2407(08)60040-3
Friedman, W. J. (1989). The representation of temporal structure in children, adolescents, and adults. In I. Levin & D. Zakay (Eds.), *Advances in Psychology*, 59. New York, NY: Elsevier.
Friedman, W.J. (1991). The development of children's memory for the time of past events. *Child Development, 62*, 139-155. doi: 10.1111/j.1467-8624.1991.tb01520.x
Friedman, W. J. (1993). Memory for the time of past events. *Psychological Bulletin, 113*(1), 44-66. doi: 10.1037/0033-2909.113.1.44
Friedman, W. J. (2014). The development of memory for the times of past events. In P. J. Bauer & R. Fivush (Eds.), *The Wiley handbook on the development of children's memory* (pp. 394–407). West Sussex, UK: Wiley-Blackwell.
Friedman, W. J., & Lyon, T. D. (2005). Development of Temporal-Reconstructive Abilities. *Child Development, 76*(6), 1202-1216. doi: 10.1111/j.1467-8624.2005.00844.x-i1
Friedman, W. J., Reese, E., Dai, X. (2011). Children's memory for the times of events from the past years. *Applied Cognitive Psychology, 25*(1), 156-165.
Lee, J. K., Wendelken, C., Bunge, S. A., & Ghetti, S. (2016). A time and place for everything: Developmental differences in the building blocks of episodic memory. *Child Development, 87*(1), 194-210. doi: 10.1111/cdev.12447
Pathman, T., Larkina, M., Burch, M. M., & Bauer, P. J. (2013). Young children's memory for the times of personal past events. *Journal of Cognition and Development, 14*(1), 120-140. doi: 10.1080/15248372.2011.641185
Pathman, T., & Ghetti, S. (2014). The eyes know time: A novel paradigm to examine the development of temporal memory. *Child Development, 85*, 792-807. doi:10.1111/cdev.12152.
Picard, L., Cousin, S., Guillery-Girard, B., Eustache, F., & Piolino, P. (2012). How do the different components of episodic memory develop? Role of executive functions and short-term feature-binding abilities. *Child Development, 83*(3), 1037-1050. doi: 10.1111/j.1467-8624.2012.01736.x
Picard, L., Reffuveille, I., Eustache, F., & Piolino, P. (2009). Development of autonoetic autobiographical memory in school-age children: Genuine age effect or development of basic cognitive abilities? *Consciousness and Cognition, 18*(4), 864-876. doi: 10.1016/j.concog.2009.07.008
Tulving, E. (1972). How many memory systems are there? *American Psychologist*, 40, 385-398. doi: 10.1037/0003-066x.40.4.385
Tulving, E. (2002). Episodic memory: From mind to brain. *Annual Review of Psychology, 53*(1), 1-25. doi: 10.1146/annurev.psych.53.100901.135114
Wechsler, D. (2011). WASI-II: Wechsler abbreviated scale of intelligence. The Psychological Corporation. San Antonio, Texas. 2011.

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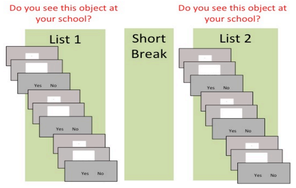
Method

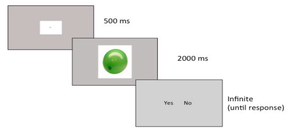
Participants:
- 7- to 9-year olds (n = 29; M_{age} = 7.89, SD = 0.84)
- 10- to 12-year-olds (n = 29; M_{age} = 11.00 , SD = 0.83)
- Young adults (n = 31; M_{age}= 21.29, SD = 3.24)

Temporal Memory Task: Encoding

Participants studied two lists of objects (50 per list), separated by a 10-minute break, and for each list indicated whether or not they saw each object at school.

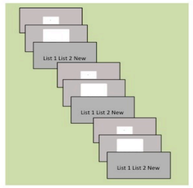


Sample Encoding Trial

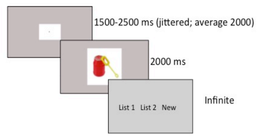


Temporal Memory Task: Retrieval

Participants viewed objects from List 1 (i.e., before the break) and List 2 (i.e., after the break) mixed with new objects, and indicated whether each object was from List 1, List 2, or New.



Sample Retrieval Trial



Retrieval strategy use: After the retrieval phase, we asked children and adults: "How did you decide whether each object was from List 1, List 2, or was New?"

Conventional Time Knowledge (CTK) task:

The CTK task measures children's and adults' ability to mentally and flexibly move through conventional time scales (Friedman, 1989; Friedman et al., 2011; Pathman & Ghetti, 2014).

Example question: "If you're going backward and you start in *May*, which would you come to first, *September* or *January*?"

Results: Temporal Context Memory

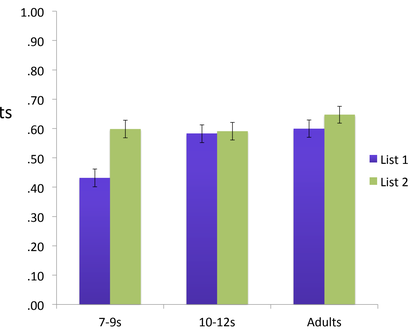
Trial

Participant Response	List 1	List 2	New
List 1 (old)	Source Hit	Source Error	False Alarm
List 2 (old)	Source Error	Source Hit	False Alarm
New	Miss	Miss	Correct Rejection

Source Hits (List 1 Hits v. List 2 Hits) x Age group ANOVA:

Main effect of Age group
$F(2, 86) = 20.151$, $p < .001$
7- to 9-year olds < 10- to -12-year olds < Adults

Main effect of List, $F(1, 86) = 5.551$, $p = .021$
- List 2 (M = .612, SE = .017) > List 1 (M = .538, SE = .017)
- T-tests reveal that this was driven by 7- to 9-year-olds



Results: Retrieval Strategy Use

We coded children's and adults' responses about strategy use using a similar system as Curran and Friedman (2003).

Code	Description
Guess	"I guessed"
Memory-general	"I used memory" "Memory"
Context retrieval	Thought about reaction to items during encoding; grouped lists according to a theme
Temporal-based	Thought about if object was before or after the break; which objects felt more recent
Other	Anything not included in other categories

Across age groups, participants who reported using either **context retrieval** or **temporal-based strategies** made more source hits than those who reported other strategies or no strategies, $F(1, 88) = 4.33$, $p = .04$

Frequencies of strategies used by children and adults

Strategy Type	7- to 9-year-olds	10- to 12-year-olds	Young adults
Guess	3	0	0
Memory-general	16	5	4
Context retrieval	3	12	7
Temporal-based	5	6	14
Other	2	6	6
Total	29	29	31

Results: Time Knowledge

We ran a multiple regression examining the influence of age, IQ (WASI), and performance on the CTK task on total proportion of source hits. The overall model was significant, and both age and CTK performance were unique predictors of proportion of source hits.

	Sum of Squares	df	Mean Square	F	Sig.
Regression	**0.206**	**3**	**0.069**	**16.223**	**.000**
Residual	0.360	85	0.004		
Total	0.566	88			

	B	Std. Error	Beta	t	Sig.
(Constant)	0.355	0.067		5.285	0.000
Age	**0.006**	**0.001**	**.464**	**4.638**	**0.000**
WASI	0.001	0.001	.092	0.975	0.332
CTK	**0.011**	**0.005**	**.236**	**2.326**	**0.022**

Conclusions & Future Directions

- We found evidence for continued development of temporal memory across middle and late childhood and into adulthood. This study adds to the literature on temporal memory development, specifically the types of processes and strategies involved in making temporal context judgments across middle and late childhood.
- The use of context- and temporal-based strategies by all age groups resulted in better memory for temporal context. Context-based strategies likely reflect the use of reconstruction processes, since participants were drawing on event details to make temporal judgments. Temporal-based strategies likely reflect the use of distance-based processes, since participants were relying on feelings of recency to make temporal judgments. The use of both types of strategies increased with age, which extends previous literature on the use of reconstruction in middle and late childhood (Friedman & Lyon, 2005; Pathman et al., 2013).
- More support for the development of controlled processing of time knowledge and flexible retrieval of that knowledge during this period comes from the finding that performance on the CTK task uniquely predicted source hits. As children's ability to flexibly think about time improves, they are better able to combine that with recall of event details to locate events in time.
- Future studies should investigate other factors that influence temporal memory development and the processes involved (e.g., reconstruction). There is evidence from a few studies that executive function contributes to temporal memory in early and middle childhood (Picard et al., 2009; Picard et al., 2012). Executive function could be especially important for children's ability to flexibly manipulate time patterns, which is essential for reconstruction.