Exploring Metacognitive Monitoring in Kindergarten: Observing Information-Seeking Behaviors in Mother–Child Reminiscing and Deliberate Memory Tasks

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INTRODUCTION

- A rich literature has documented how the use and effectiveness of appropriate strategies for remembering improve across the elementary school years (Ornstein, Haden, & San Souci, 2008).
- Notably, the association between deliberate strategy use and recall is not strong until first grade (Schneider, 2011). This may be due, in part, to differences in individual-level factors such as *metacognition* (Blair & Diamond, 2008; Kuhn, 1999).
- In younger children, *information-seeking behaviors,* such as asking questions, have been examined as components of *metacognitive monitoring*, or children's detection of a comprehension or compliance issue when presented with an ambiguous goal (Revelle et al., 1985; Flavell et al., 1981).
- Although children enter formal school with considerable variability in metacognitive skills (Roebers, 2014; Schneider, 2015), limited research has focused on associations between metacognition and the development of children's deliberate memory skills over time.
- Therefore, the following study aims to build upon recent work linking reminiscing conversations to deliberate memory outcomes (Langley et al., 2017) by examining linkages between (a) parent and child elaborations, (b) children's information-seeking behaviors in two contexts, and (c) children's deliberate memory skills.

AIMS OF THE STUDY

- To characterize parent and child contributions in reminiscing conversations, specifically elaborations and information-seeking memory questions posed by children.
- To explore information-seeking behaviors in an ambiguous goal task.
- To examine linkages between parent and child elaborations, information-seeking behaviors, and deliberate strategy use over the kindergarten year.

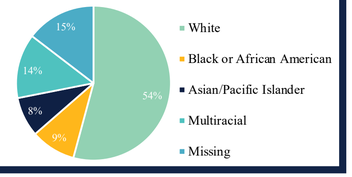
METHODS

- Data for this study were drawn from an ongoing longitudinal study of children's memory and cognitive skills as they transition into elementary school.
- Child-, home- and school-level measures were collected across the kindergarten year.
- Continuing data collection will allow for multi-level assessments through the beginning of the second grade.

PARTICIPANTS

Participants were drawn from 5 schools and included 96 kindergarteners:

- 42 Males, 54 Females
- Age Range: 4.93 to 6.47 years



MEASURES

Information-Seeking in Parent–Child Conversations

- Parent-child dyads took part in the Mother–Child Reminiscing Task (Reese et al., 1993); parents were asked to discuss two novel, shared, one-time events with their child.
- Conversations were audio-recorded, transcribed, and then coded using a structural/functional coding system (adapted from Reese et al., 1993).
- Particular attention was paid to both existing measures of parent and child contributions to conversations, such as *elaborations*, but also to children's *memory questions*: an indicator of information-seeking behaviors.

Parent Codes	Definition
Elaborations	*Utterances* that provide additional or new information about the event under discussion or *questions* that either ask the child for new information or to confirm or deny a piece of memory information

Child Codes	Definition
Memory Elaboration	Children's utterances that provide additional or new information about the event under discussion
Memory Question	Children's "open-ended" memory questions, asking the parent to provide information

Information-Seeking During a Task with an Ambiguous Goal

- Children took part in an Object Memory Task (OBJ; Baker-Ward et al., 1984) in which they were asked to "work to remember" as many objects as possible, but not given any specific directions on how to do so, during a 2-minute study period. This resulted in a variety of behaviors – as the best way to achieve this goal was intentionally ambiguous.

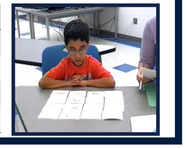
Spontaneous information-seeking behaviors were coded and described below:

Indicator	Examples
Information-Seeking Behaviors	The number of times a child asked the research assistant for the name of an unknown object
Latency to Seek Information (sec)	The length of time in seconds it takes to seek information for the first time

Deliberate Memory Skills

- Children took part in the Free Recall Task with Organizational Training (Moely et al., 1992); children were asked to remember 16 line drawings (from 4 categories; see below). First, children completed a baseline trial (measuring spontaneous sorting), followed by a training trial in which they were instructed in categorical organization, and finishing with a generalization trial that served as an indicator of their abilities to take advantage of this strategic instruction.
- The Adjusted Ratio of Clustering (ARC) measure (Roenker, Thompson, & Brown, 1971) was used to characterize children's sorting during study; the measure ranges from -1 (below chance) to 0 (chance) to 1 (perfect categorical sorting and clustering).

Category	Line Drawings			
Clothing	Pants	Shorts	Shirt	Socks
Plants	Flower	Cactus	Tree	Grass
Furniture	Couch	Table	Bed	Chair
Toys	Block	Teddy bear	Yo-yo	Ball



WITHIN AND ACROSS TASK RESULTS

Characterizing Parent–Child Reminiscing Conversations

Figure 1. Sample of Coding Parent–Child Reminiscing

Transcription	Codes
P: We ate, did you see anything at Cinderella's castle at night time?	Confirmation; General memory question elaboration
C: Fireworks and Tinkerbell!	Memory Elaboration x2
P: What did Tinkerbell do?	General memory question elaboration
C: She flew over Cinderella's castle!	Memory elaboration
P: And what did she do? Did she light it up? That was super fun, wasn't it?	General memory question elaboration; Yes-no elaboration x2
C: How did she light it up?	Memory Question
P: With her little wand.	Statement elaboration

Descriptive Statistics by Construct

Information-Seeking in Parent–Child Conversations

Variable	Min	Max	Mean	SD
Parent Elaborations	7.5	119	38.90	20.73
Child Memory Elaborations	2	84	24.52	14.76
Child Memory Questions	0	3	.60	.78

Information-Seeking During an Ambiguous Goal

Variable	Min	Max	Mean	SD
Frequency of Information-Seeking	0	3	0.22	0.55
Latency to Seek Information (sec)	5	126	109.76	33.30

Note: *Latency to Seek Information* is reverse scored, in that a smaller score indicates it took the child fewer seconds to seek information, exhibiting greater metacognitive monitoring.

Deliberate Strategy Use

Variable	Min	Max	Mean	SD
Fall Spontaneous Sorting	-.23	.78	-.21	.11
Fall Generalization Sorting	-.23	1	.03	.47
Winter Spontaneous Sorting	-.23	1	.05	.50
Spring Spontaneous Sorting	-.23	1	.10	.53

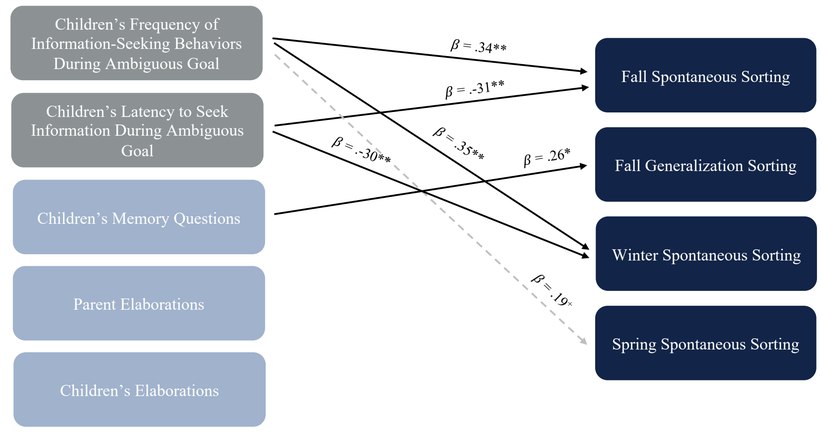
Correlations Between Predictor Variables

	1.	2.	3.	4.
1. Parents' Elaborations	-			
2. Children's Elaborations	.73**	-		
3. Children's Memory Questions	.43**	.34**	-	
4. Info-Seeking Freq. on OBJ	.13	.03	.24+	-
5. Info-Seeking Latency on OBJ	-.27*	-.13	-.39**	-.84**

- Children's memory questions, but not their elaborations, were significantly associated with their latency to seek information and marginally associated with their total frequency of information-seeking behaviors when presented with an ambiguous goal.

+p<.10, *p<.05, **p<.01

ACROSS TASK RESULTS



Note: Although all pathways were tested, only significant and marginal effects are illustrated above. +p<.10, *p<.05, **p<.01

- Children's total frequency of information-seeking behaviors and their latency to seek information when presented with an ambiguous goal predicted their spontaneous, strategic sorting skills in the fall ($\beta = .34$, $p < .001$; $\beta = -.31$, $p = .003$) and winter ($\beta = .34$, $p < .001$; $\beta = -.31$, $p = .004$) of kindergarten.
- However, it was children's information-seeking behaviors during parent-child reminiscing conversations that predicted children's ability to successfully *take up* and *apply* strategic organizational training when taught by a research assistant ($\beta = .26$, $p = .03$).
- Neither parents' nor children's elaborations predicted children's deliberate strategy use.

DISCUSSION AND FUTURE DIRECTIONS

- These findings address a gap in the literature surrounding the assessment of young children's emergent metacognitive monitoring skills. Children who *quickly* and *frequently* sought information when presented with an ambiguous goal evidenced greater spontaneous strategy use on a deliberate memory task. Indeed, previous research has suggested that metacognitive skills may serve as a precursor to effective strategy use (Schlagmüller & Schneider, 2002) and may be linked to children's ability to identify the *need for* and *appropriately select* a strategy (Schneider, 1999).
- Findings highlight the role of children's information-seeking behaviors during reminiscing conversations as potential indicators of metacognitive monitoring – or acknowledging what one does not know and subsequently seeking out this information. In the current study, children who frequently posed open-ended questions to their parents were quicker to autonomously seek out information from a research assistant when presented with an ambiguous goal than their peers who posed fewer memory questions when reminiscing.
- Given that there are almost no short-term longitudinal studies examining children's emergent metacognitive skills (Roebers, 2017), future work would benefit from examining the role of reminiscing conversations on longitudinal change in children's metacognition throughout the academic year – as early metacognitive monitoring is thought to set the stage for more advanced study techniques into adolescence (Weil et al., 2013).

ACKNOWLEDGEMENTS

Thank you to the children, families, teachers, and research assistants who make this work possible. The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305A170637 to the University of North Carolina at Greensboro. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.

“How Did You Study the Passage?”: Exploring Linkages Between Basic Cognitive, Academic, and Study Skills

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INTRODUCTION

- The ability to study and retain information from content-relevant text passages is a critical skill for academic success. Past research has focused primarily on the strategic study behaviors of university students (Crede & Kuncel, 2008). Few studies have examined these skills in elementary school students.
- Little is known about how students acquire these skills and the factors that are associated with their effective use. Coffman et al. (2019) found associations between children’s early organizational memory strategies and later strategic study behaviors. Thus, study skills may be related to general cognitive skills.
- Longitudinal studies have linked both domain-general and domain-specific skills to academic performance and strategy selection (e.g., Lemaire & Lecacheur, 2011; Suggate et al., 2018).
- Nevertheless, associations between academic skills, basic cognitive abilities, and strategic studying have not been examined in elementary students.

AIMS OF THE STUDY

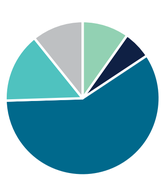
- To characterize the spontaneous study behaviors used by students and describe how strategically they employed each behavior.
- To examine links between kindergarten children’s basic cognitive abilities, academic skills, and performance on a study skills task in third grade (study strategies and recall performance).

METHODS

- Data for this study were drawn from a longitudinal study of children’s memory and cognitive skills across the early elementary school years.
- Child- and school-level measures were collected from kindergarten entry through the beginning of the third-grade year.
- Kindergarten measures were obtained during in-person assessments. However, due to the COVID-19 pandemic, the study skills task was conducted via Zoom.

PARTICIPANTS

- 102 second- and third-grade students
- 43 male, 59 female
- Average age during study skills task: 8.43 years (range: 7.57 – 9.46)

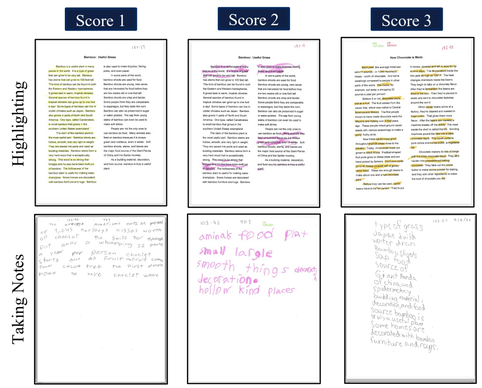


MEASURES

Study Skills (adapted from Brown & Smiley 1977; 1978)

- Children were given 4 minutes to work to remember a non-fiction passage. They were provided a piece of paper, pencil, and highlighter but given no explicit study instructions.
- Recall for each fact from the passage was scored 0 (no recall), 1 (partial recall), or 2 (full recall). Recall scores reflect the sum of scores across all facts (51 in total).
- For each of the study behaviors defined below, strategy use was scored from 0 (not present) to 3 (strategic and systematic focus on key information). A composite score was created using the average of the observed strategies.

Study Behavior	Definition
Underlining	Degree to which students strategically underlined key facts
Highlighting	Degree to which students strategically highlighted key facts
Taking Notes	Degree to which students strategically took notes on key facts or summarized important details in their own words
Reviewing Notes	Degree to which students reviewed notes in a strategic manner
Drawing a Picture	Degree to which students drew an organized picture of key facts
Verbalization	Degree to which students rehearsed or reread specific facts aloud
Self-Testing	Degree to which students strategically self-tested, focusing on key facts
Rereading	Degree to which students strategically and systematically reread (e.g., in the service of taking notes)



Dimensional Change Card Sort (DCCS; Gerson et al., 2013)

- Children were asked to match a set bivalent cards to two target pictures. First, they sorted by one dimension (e.g., shape) and then according to the other (e.g., color). This task assesses cognitive flexibility.

Woodcock Johnson Reading Fluency (Woodcock et al., 2001)

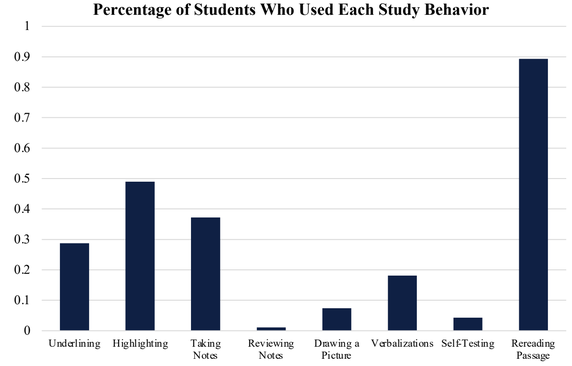
- Children were given three minutes to read a series of sentences and indicate whether each statement was true or false. This task assesses children’s reading fluency.

DESCRIPTIVE STATISTICS

Study Skills Strategy Use and Recall Performance

	N	Min	Max	Mean	SD
Strategic Behaviors Composite	94	0.00	3.00	2.00	0.66
Recall	100	0.00	30.00	12.08	7.13

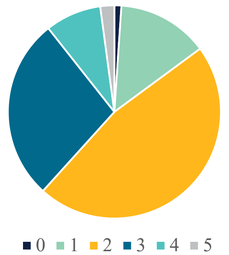
Percentage of Students Who Used Each Study Behavior



Strategy Score by Study Behavior

Study Behavior	Mean *(SD)*
Underlining	1.85 *(0.77)*
Highlighting	1.70 *(0.70)*
Taking Notes	1.83 *(0.75)*
Reviewing Notes	1.00 *(0.00)*
Drawing a Picture	1.57 *(0.79)*
Verbalization	1.82 *(0.81)*
Self-Testing	1.50 *(0.58)*
Rereading	2.49 *(0.72)*

Number of Behaviors Used



- Students used a range of study strategies. Rereading (used by 89.36% of students) and highlighting (48.94%) were the most common and reviewing notes (1.06%) was the least. Children used a mean of 2.35 different strategies (range = 0 – 5).
- The overall composite of strategic behaviors ranged from 0 to 3 with a mean of 2.00 and standard deviation of 0.66.
- Recall ranged from 0 to 30, with an average score of 12.08 (*SD* = 7.13).

Basic Cognitive and Academic Skills

	N	Min	Max	Mean	SD
Reading Fluency	73	0	46	6.37	9.58
Cognitive Flexibility	94	0.13	7.68	4.21	2.30

- During kindergarten, children varied in both their reading fluency and cognitive flexibility. Raw scores were used for reading fluency and a computed score of reaction time and accuracy for cognitive flexibility.

RESULTS

Linking Basic Cognitive and Academic Predictors to Study Skills

- Children’s kindergarten skills (cognitive flexibility and reading fluency) were correlated with both their composite strategy behaviors and recall scores (*r*s=.25 to .39; *p*s<.05).
- Additionally, strategy use and recall were significantly correlated (*r*=.36, *p*<.01).

Regression Predicting Study Skills Using Kindergarten Abilities

	B	*SE B*	*β*	R^2
Kindergarten Reading Fluency	.01	.01	.21	.04
Kindergarten Cognitive Flexibility	.11	.03	.37**	.14

*p <.05 **p <.01

Regression Predicting Recall Using Kindergarten Abilities

	B	*SE B*	*β*	R^2
Kindergarten Reading Fluency	.28	.08	.38**	.14
Kindergarten Cognitive Flexibility	.48	.35	.15	.02

*p <.05 **p <.01

- Children’s kindergarten skills were correlated with both their composite strategy behaviors and recall scores. Additionally, strategy use and recall were significantly correlated.
- Regression results revealed that strategy use was predicted by cognitive flexibility but not reading fluency. Notably, the opposite findings occurred for recall performance; recall was predicted by reading fluency but not cognitive flexibility.

DISCUSSION AND FUTURE DIRECTIONS

- The findings from this study provide evidence that elementary school students are capable of employing study strategies spontaneously while working to remember a non-fiction passage. Children varied both in terms of the behaviors that they used and how strategically they applied each skill.
- Notably, their strategic studying was significantly correlated with their recall performance.
- Students with higher cognitive flexibility in kindergarten were more strategic in their study attempts, whereas students with stronger reading skills recalled more facts from the passage. This suggests that early cognitive and academic competencies may differentially contribute to later, more advanced study skills.
- Future work can investigate how elementary students study other types of passages. Additionally, little is known about how concurrent academic and cognitive skills contribute to study skills. There may be other important cognitive and academic skills that support strategic efforts. Finally, additional research is necessary to understand how children develop these study skills during the elementary school years.

ACKNOWLEDGEMENTS

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Parental Math Attitudes and Expectations Predict Developmental Change in Children's Mathematical Skills in Elementary School

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INTRODUCTION

- The home mathematics environment encompasses a wide range of factors such as parents' personal attitudes and affective responses to mathematics, activity choices, and the resources available to support mathematical learning (Elliot et al., 2021).
- Multiple studies have evidenced positive associations between home mathematics learning practices – such as the frequency of parental scaffolding and access to educational materials – and children's mathematical performance (Sénéchal et al., 2017).
- However, recent evidence has suggested that this association is more nuanced than previously understood (Skwarchuk et al., 2022) and that caregivers' personal attitudes towards mathematics may play a more prominent role in children's development than previously understood, as they may contribute to the quality of formal numeracy activities taking place in the home (del Río et al., 2017).
- For this reason, further investigation is required to understand the unique roles that parents' mathematical attitudes, expectations, and home numeracy practices play in children's mathematical skills during early elementary school.

AIMS OF THE STUDY

1. Describe children's development of mathematical strategies across kindergarten and first grade.
2. Examine associations between parental math attitudes and home numeracy practices.
3. Predict children's change over time in math problem solving skills from these parent-level predictors.

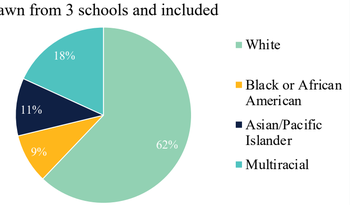
METHODS

- Data for this study were drawn from an ongoing longitudinal study of the memory and cognitive skills of children as they transition into elementary school.
- Child-, home- and school-level measures were collected across fall, winter, and spring of the kindergarten and first-grade years, totaling six timepoints.
- Continuing data collection will allow for multi-level assessments through the beginning of the second grade.

PARTICIPANTS

Participants were drawn from 3 schools and included 67 kindergarteners:

- 32 males
  35 females
- Age Range:
  4.93 – 6.43 yrs.



MEASURES

Formal Home Numeracy Practices (Skwarchuk et al., 2014)

- In the fall of kindergarten, primary caregivers reported the frequency of practicing specific numeracy activities in the home with their children
- Possible responses ranged from *rarely/never* (0) to *multiple times daily* (4)
- Responses were averaged to create a composite measure representing the home numeracy environment.

Example indicators on the Questionnaire (How often do you...?)	
help learn simple sums?	help child weigh, measure, or compare quantities?
ask about quantities?	help child recite numbers in order?
sing counting songs?	teach child to recognize printed numbers?
play board games or cards?	sort and classify by color, shape, and size?

Parents' Mathematical Attitudes and Numeracy Expectations (Skwarchuk et al., 2014)

- In the fall of kindergarten, to assess parents' personal attitudes towards mathematics/numeracy, primary caregivers rated their agreement (0 = *strongly disagree* to 4 = *strongly agree*) on 4 statements listed below.
- To assess caregivers' knowledge of appropriate numeracy expectations for young children, primary caregivers indicated the importance (1 = *unimportant* to 5 = *extremely important*) that children achieve 3 number of numeracy benchmarks before they start first grade.
- Responses were averaged to create a composite measure representing the parents' mathematics attitudes and numeracy expectations, respectively.

Numeracy Attitudes	Academic Expectations (Numeracy)
Rate your agreement with the following statements:	How important is it for your child to…
"I was good at math when I was in school."	• Count to 100
"I enjoyed math when I was in school."	• Read printed numbers up to 100
"The career path I've chosen in math-related."	• Know simple sums (e.g., 2 + 2)
"I find math activities enjoyable."	

Children's Mathematical Problem Solving (Siegler & Jenkins, 1989)

- Children solved ten simple addition problems that were coded for strategy use across all 6 timepoints.
- Two indicators of math problem-solving skills were assessed:
  1. Accuracy (i.e., total correct answers)
  2. Strategy effectiveness (i.e., the percentage of the 10 problems on which children employed a strategy and it resulted in the correct answer.)

Strategy	Description
1. Sum	Counting numbers from the problem starting from 1
2. Shortcut Sum	Count two numbers together starting with one
3. Max	Counting on from the smaller addend
4. Min	Counting on from the larger addend
5. Finger Recognition	Shows the number on fingers with out counting
6. Decomposition	Relied on information from an easier problem to solve

ACROSS TASK RESULTS

Characterizing Numeracy Practices, Attitudes, and Expectations

Parent-Level Predictor Variables

Variable	Min	Max	Mean	SD
Formal Numeracy Practices	.42	3.75	2.09	.88
Parents' Mathematical Attitudes	.50	4.00	2.69	1.01
Parents' Numeracy Expectations	1.00	4.00	3.05	.84

- All composite scores were created by averaging across all indicators within each questionnaire (e.g., the mathematical attitudes composite is an average of parents' responses across those 4 indicators).
- Parents' math attitudes and numeracy expectations were significantly associated with one another ($r = .30$, $p < .05$). Numeracy practices were only marginally associated with parents' numeracy expectations ($r = .23$, $p < .10$).

Parent-Level Variables Predicting Children's Development

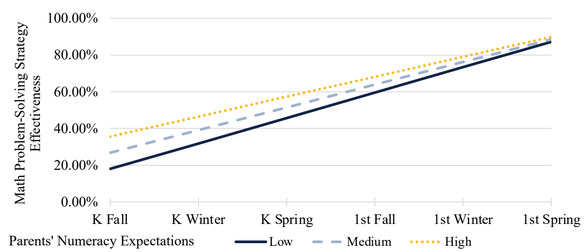
Scaling Outcome Variables

Variable	Lowest Possible Score for Each Timepoint	Highest Possible Score for Each Timepoint
Accuracy	**0**	**10**
Strategy Effectiveness	**0%**	**100%**

Conditional Hierarchical Linear Model Results

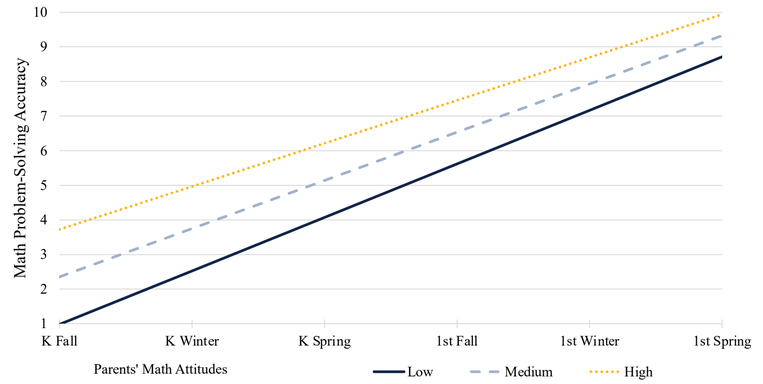
Final Estimation of Fixed Effects	*Coefficient*	*SE*	*t*	*df*	*p*
Children's Math Problem-Solving Accuracy					
Intercept	6.28	0.65	9.69	65	<.001
Time	1.39	0.20	7.00	307	<.001
Math Attitudes	**0.47***	0.23	**2.10**	65	**0.04**
Math Attitudes * Time	**-0.15***	0.07	**-2.16**	307	**0.03**
Intercept	5.71	0.86	6.67	65	<.001
Time	1.51	0.26	5.70	307	<.001
Numeracy Expectations	**0.61***	0.27	**2.24**	65	**0.03**
Numeracy Expectations * Time	**-0.17***	0.08	**-2.03**	307	**0.04**
Children's Math Problem-Solving Strategy Effectiveness					
Intercept	.64	.07	8.74	65	<.001
Time	.12	.03	3.75	307	<.001
Numeracy Expectations	**.05***	.02	**2.23**	65	**0.02**
Numeracy Expectations * Time	-.02⁺	.01	-1.71	307	0.08

Note: Although all six possible models were run, only models with significant effects are shown above. For all models, the intercept is specified to first grade entry (Time 4).



ACROSS TASK RESULTS

Predicting Children's Math Problem-Solving Accuracy



- Children of parents with more positive attitudes towards math and higher numeracy expectations evidenced ***higher math problem solving accuracy*** from the fall of kindergarten through first grade entry than their peers of parents with more negative attitudes towards math and lower numeracy expectations ($\gamma_{10} = .47$, $p = .04$; $\gamma_{10} = .61$, $p = .03$).
- However, children with parents who had negative mathematical attitudes and lower numeracy expectations developed ***more rapidly*** over the course of the kindergarten and first grade year ($\gamma_{11} = -.15$, $p = .03$; $\gamma_{11} = -.17$, $p = .04$).
- Similarly, children of parents with high numeracy expectations evidenced ***greater strategy effectiveness*** scores from the fall of kindergarten through beginning of first grade than their peers of parents with lower numeracy expectations ($\gamma_{10} = .05$, $p = .02$).
- Parents' home numeracy practices did not account for differences in children's math problem-solving accuracy or strategy effectiveness.

DISCUSSION AND FUTURE DIRECTIONS

- Contrary to previous research, parents' home numeracy practices did not predict children's math problem solving skills at any timepoint in the current study. Rather, parents' math attitudes and numeracy expectations were associated with differences in children's skills throughout the first year of elementary school and their performance at first-grade entry. Future work would benefit from examining if the positive association between parents' attitudes and expectations and children's mathematics performance is mediated by home numeracy practices (LeFevre et al., 2002).
- Additionally, children of parents with more negative attitudes and lower numeracy expectations developed accuracy scores *more rapidly* over the course of kindergarten and first grade, highlighting the importance of examining the role of the schooling experience for specific subgroups of children. The examination of the interplay between home- and school-level processes on children's math problem-solving development is a clear next step for researchers (Hudson et al., 2018).

ACKNOWLEDGEMENTS

Thank you to the children, families, teachers, and research assistants who make this work possible. The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305A170637 to the University of North Carolina at Greensboro. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.

The Delayed Role of Kindergarten: Linkages Between Teachers' Cognitive Processing Language and Children's Memory Skills

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INTRODUCTION

- The early elementary school years mark a significant period of growth in children's deliberate memory skills (see Ornstein et al., 2008, Sodian & Schneider, 1999). Longitudinal studies have provided evidence that meaning-based sorting (grouping semantically-related items) increases between kindergarten and second grade (Kron-Sperl et al., 2008).
- Past experimental and longitudinal studies have linked teachers' use of metacognitively-rich instructional language (termed Cognitive Processing Language or CPL) to children's growing memory skills (see Coffman & Cook, 2021, for a review).
- Children exposed to higher levels of CPL in first grade engage in more strategic sorting at the end of the school year, with differences persisting through fourth grade (Coffman et al., 2019). However, little is known about these associations in kindergarten.
- Kindergarteners are less strategic than first-grade students and less able to take up strategy training (Coffman et al., 2011). Thus, associations between exposure to high levels of CPL in kindergarten and strategic behaviors may not be evident until later grades.

AIMS OF THE STUDY

In this examination of growth in children's deliberate memory skills as a function of their kindergarten classroom experiences, we aim to:

1. Explore developmental change in children's strategic sorting across the kindergarten and first-grade school years.
2. Examine whether kindergarten teachers' use of higher compared to lower levels of Cognitive Processing Language predicts differences in developmental trajectories.

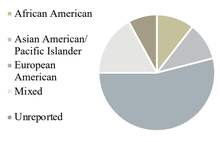
METHODS

- Data for this study were drawn from the first cohort of an ongoing longitudinal study of children's memory and cognitive skills as they transition into elementary school.
- Child- and school-level measures were collected across the kindergarten and first grade years.

PARTICIPANTS

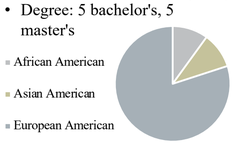
Children

- 76 children (41 girls, 35 boys)
- Age at K Fall Timepoint: 5.72 years (4.93–6.43)



Teachers

- 10 teachers (all female)
- Age: 36.10 years (24–53)
- Experience: 13.40 years (2–30)
- Degree: 5 bachelor's, 5 master's



MEASURES

Free Recall with Training: FRT (Moley et al., 1992)

- Children were asked to remember 16 drawings (from 4 categories).
- During fall of kindergarten and first grade, children completed a *baseline* trial (measuring spontaneous sorting), a *training* trial where they received instructions on categorical organization, and a *generalization* trial (assessing their ability to utilize this strategic instruction with new materials).
- At the winter and spring timepoints, children completed a single trial with new drawings from 4 new categories.
- As children worked to remember, their strategic sorting was measured using an Adjusted Ratio of Clustering (ARC) score (Roenker et al., 1971). Sorting ARC scores range from –1 (below chance) to 0 (chance sorting) to +1 (perfect categorical sorting).

Example Set

Category	Line Drawings			
Clothing	Pants	Shorts	Shirt	Socks
Plants	Flower	Cactus	Tree	Grass
Furniture	Couch	Table	Bed	Chair
Toys	Blocks	Teddy Bear	Yo-yo	Ball

Cognitive Processing Language: CPL (Coffman et al., 2008)

- A cumulative total of 120 minutes of whole-group language arts and mathematics instruction was videotaped and coded for each classroom.
- Observations were collected over several months and required an average of 12.8 lessons (range = 10–16). Lessons ranged from 3 to 17.5 minutes and lasted an average of 9.78 minutes.
- Teachers' language was coded every 30 seconds using a coding scheme characterized by 26 codes from four main categories:

  (1) *Instructional Activities* (giving instructional information)

  (2) *Cognitive Structuring Activities* (encouraging deeper processing)

  (3) *Memory Requests* (asking to recall or remember for the future)

  (4) *Metacognitive Information* (asking/giving strategic information)
- A composite index of Cognitive Processing Language (CPL) was created based on a subset of codes:

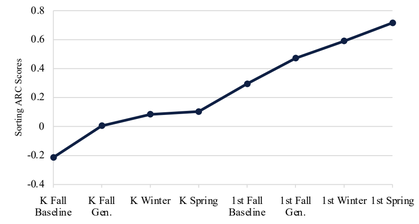
Code	Definition
Strategy Suggestions	Recommending that a child adopt a procedure for remembering or processing information
Metacognitive Questions	Requesting that a child provide a potential strategy, a utilized strategy, or rationale for a utilized strategy
Co-occurrence of Memory Requests and Instructional Activities	Requesting information from children's memory while also presenting instructional information
Co-occurrence of Memory Requests and Cognitive Structuring Activities	Requesting information from children's memory while simultaneously facilitating encoding and processing by focusing attention or organizing materials
Co-occurrence of Memory Requests and Metacognitive Information	Requesting information from children's memory while providing or soliciting metacognitive information

DESCRIPTIVE STATISTICS

Sorting ARC Scores Across Kindergarten and First Grade

Time Point	N	Mean	SD
Kindergarten Fall Baseline	76	-0.21	0.12
Kindergarten Fall Generalization	72	0.01	0.46
Kindergarten Winter	73	0.08	0.53
Kindergarten Spring	73	0.10	0.52
First Grade Fall Baseline	65	0.30	0.59
First Grade Fall Generalization	65	0.47	0.60
First Grade Spring	64	0.59	0.57
First Grade Winter	64	0.72	0.50

Mean Sorting ARC Scores Over Time



Children increased in their strategic sorting across the kindergarten and first-grade school years. At the beginning of kindergarten, children sorted at below chance levels (most students did not perform any sorting); at the end of the school year, they sorted slightly above chance. By the end of first grade, children sorted significantly above chance (approximately 14/16 cards).

Classroom-Level Factors

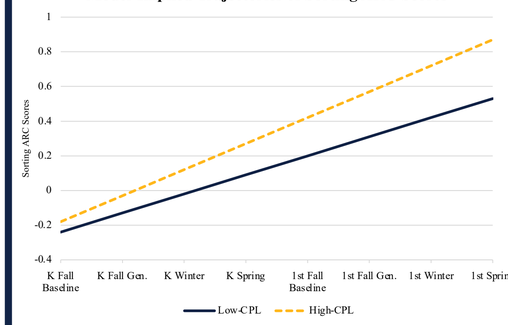
Taxonomy Codes	Overall Mean *(Range)*	Low CPL Mean *(Range)*	High CPL Mean *(Range)*
Strategy Suggestions	14.83% *(2.50%–27.50%)*	12.42% *(2.50%–22.08%)*	17.25% *(10.83%–27.50%)*
Metacognitive Questions	11.17% *(5.00%–21.67%)*	8.00% *(5.00%–12.08%)*	14.33% *(6.67%–21.67%)*
Co-occurrence of Memory Requests with:			
Instructional Activities	55.46% *(47.50%–65.83%)*	51.58% *(47.50%–54.58%)*	59.33% *(50.42%–65.83%)*
Cognitive Structuring Activities	30.96% *(21.67%–42.92%)*	25.42% *(21.67%–33.33%)*	36.50% *(23.75%–42.92%)*
Metacognitive Information	15.00% *(6.67%–22.08%)*	12.00% *(6.67%–16.67%)*	18.00% *(12.08%–22.08%)*

- Standardized scores were generated for each component of CPL.
- Each of the resulting *T* scores was averaged to create a composite index of CPL. The mean *T* score was 50 (*SD* = 7.56) with a range of 38.44 to 61.15.
- Teachers were divided into high and low groups based on a median split for comparison. The table displayed above shows the percentage of intervals in which teachers used each type of language (mean scores and ranges are displayed).

RESULTS

Children's Sorting ARC Scores Predicted by Kindergarten Teachers' CPL

Model-Implied Trajectories of Sorting ARC Scores



- Children taught by the two groups of teachers displayed similar initial sorting scores (low-CPL = -0.23, high-CPL = -0.20); however, the two groups diverged across the school years.
- A series of hierarchical linear models was used to assess developmental trajectories in students' sorting behaviors as a function of their teachers' use of CPL.
- Children who were taught by kindergarten teachers who used high levels of CPL had significantly higher sorting scores at the end of first grade (p=.006). Moreover, these students also developed strategic sorting skills ***more rapidly*** than their peers who were exposed to low levels of CPL (p=.013).

Fixed Effects	Coefficient	*SE*	*t*	*p*	95% Confidence Interval Lower	Upper
Intercept	0.53	0.09	6.04	<0.01	0.36	0.71
Time	0.11	0.01	8.56	<0.01	0.08	0.13
Teachers' CPL	0.34	0.12	2.83	0.01	0.10	0.57
Teachers' CPL*Time	0.04	0.02	2.49	0.01	0.01	0.08

Note: Intercept is specified to the end of first grade. Intercepts and slopes did vary randomly, although only fixed effects are presented here.

DISCUSSION AND FUTURE DIRECTIONS

- This is the first investigation to examine the role of kindergarten teachers' use of CPL in children's growth in deliberate memory skills. At the end of first grade, children's use of strategic sorting differed as a function of their exposure to high, as compared to low levels of CPL in kindergarten. Notably, children exposed to higher levels of CPL also evidenced a more rapid rate of change over two academic years.
- Novel findings from this study suggest that experiences in kindergarten may continue to play a role in children's development of strategic memory even after they transition to first grade. Early exposure to metacognitively-rich instructional language may therefore prepare students to take advantage of instruction in subsequent grades.
- Building on these findings, future studies would benefit from examining the influence of exposure to sustained, high levels of CPL across multiple school years. Specifically, researchers should explore whether receiving metacognitively-rich instructional language two years in a row would enhance deliberate memory outcomes. Replicating this study with a larger, more diverse sample would test the generalizability of these findings and allow further analyses. Indeed, it remains unknown *how much* and *how often* exposure to CPL is optimal for children's memory development.

ACKNOWLEDGEMENTS

Thank you to the children, families, teachers, and research assistants who make this work possible. The research reported here was supported by the Institute of Education Sciences, U.S. Department of Education, through Grant R305A170637 to the University of North Carolina at Greensboro. The opinions expressed are those of the authors and do not represent views of the Institute or the U.S. Department of Education.