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Relating Children's Early Elementary Classroom Experiences to Later Skilled Remembering and Study Skills

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The work on children's memory and study skills reported here stems from a research program that involves an active collaboration between researchers and practitioners. The initial impetus for the work can be seen in a search for mechanisms underlying the development of children's basic memory skills. Our orienting assumption was that even though much was known about age differences in children's use of strategies such as rehearsal and organization, little information was available on the development of these techniques within individual children, and even less was understood about the social forces that support the emergence and refinement of these skills (Ornstein & Haden, 2001). A concern for these issues led researchers to move from the laboratory to the classroom (Moely et al., 1992; Coffman, Ornstein, McCall, & Curran, 2008), a social context that comparative-cultural research had linked to the development of children's strategies (e.g., Scribner & Cole, 1978). From the beginning, however, it was clear that effective research would require serious consultation with administrators and classroom teachers. Over the course of carrying out a series of longitudinal and experimental studies, what started as fundamental research that was influenced by both the information processing and social constructivist traditions (see, e.g., Ornstein, Coffman, Grammer, San Souci, & McCall, 2010) and rooted in basic cognitive and developmental science was transformed into an endeavor with applied implications, reflecting both interests and needs of the schools.

This article is structured to reflect this collaborative journey, beginning with the basic research in which the work was initially embedded and ending with a discussion of what can be achieved when research on cognitive development is carried out in the schools with active input from educators. Along the way, we discuss the gains that are possible when researchers and educators form a symbiotic partnership to ask questions that increase fundamental understanding of cognitive development and that have implications for increasing children's success in the classroom. In the process, we demonstrate that not only can basic research on children's cognition contribute to the mission of the schools, but also that collaboration among researchers and educators can lead to changes in research designs that enable researchers to ask different and perhaps better questions.

Children's Strategic Memory and its Development

A rich database concerning age-related changes in the generation of memory strategies (Ornstein, Haden, & San Souci, 2008) shows convincingly that as children progress through elementary school they become more proficient in the use of techniques for the storage and retrieval of information. Much of this database is based on assessing children of different ages on memory tasks that reflected the influence of the information processing perspective in cognitive psychology on researchers in experimental child psychology (for historical accounts, see, e.g., Baker-Ward & Ornstein, 2014; Schneider & Ornstein, 2015). For example, in the context of tasks that involve the deliberate memorization of sets of words or pictures, there is a very systematic transition across the elementary school years from relatively passive to more active techniques of remembering (Schneider & Pressley, 1997). Moreover, although initial studies of rehearsal, organization, and elaboration were essentially correlational in scope, later work included training manipulations so that causal linkages between strategy use and remembering could be made (e.g., Ornstein, Medlin, Stone, & Naus, 1985). Still later explorations were designed to examine the context specificity of children's strategic efforts and to carry out in-depth analyses of factors (e.g., prior knowledge, effort requirements) that contribute to strategy effectiveness (Ornstein, Baker-Ward, & Naus, 1988).

In contrast to this rich literature on basic memory strategies, relatively little research has focused on study skills such as note taking, outlining, and underlining that are of critical importance for children's success on academically-based tasks in the later elementary school. Although Brown and Smiley (e.g., 1977, 1978; see also Brown, Bransford, Ferrera, & Campione, 1983) carried out important pioneering work on these skills, little is known about the ways in which children of different ages approach tasks that require studying and integrating material. Moreover, still less is understood about the development of these skills over the course of the elementary school years. Thus, for example, it is important to investigate the extent to which mastery of "simple" techniques such as rehearsal and organization in the early years of elementary school provides the foundation for later success in the use of more complex study skills in the later school years.

A developmental analysis of children's early and later strategic efforts requires both longitudinal methods in which the progression of skill can be traced within individual children (see Ornstein & Haden, 2001; Schneider & Ornstein, 2015) and the exploration of

factors that may influence the emergence and refinement of these techniques for remembering and studying. This investigation was thus motivated by the need to characterize children's changing skills, while also examining forces in the children's lives thought to influence their development. Our approach to these questions is guided by an integration of theoretical perspectives. We make use of information processing methodologies for assessing children's changing memory and cognitive skills (e.g., Schneider & Pressley, 2013) and sociocultural theory (e.g., Gauvain, 2001; Rogoff, 1990; Vygotsky, 1978) for describing the socialization of abilities in the home and classroom contexts. In this paper, we use this integrated approach and present longitudinal findings describing associations among children's strategic behaviors in memory and study skills tasks, as well as long-term linkages between students' early schooling experiences and their later strategic efforts.

Schooling and the Development of Memory

Early evidence of the importance of schooling for the development of memory skills came from comparative-cultural investigations that were designed to examine the impact of formal schooling on children's cognition. Researchers such as Rogoff (1981), Scribner and Cole (1978), and Wagner (1978) demonstrated that attendance in school seemed to be necessary for children to acquire and make use of organizational techniques for remembering. Additional support for the view that formal schooling is important for the development of mnemonic skills came from the work of Morrison and his colleagues (Christian, Bachman, & Morrison, 2001) who examined the impact of the elementary school classroom on aspects (e.g., reading, memory) of children's cognitive development. More specifically with regard to memory, Morrison, Smith, and Dow-Ehrensberger (1995) developed a "cutoff" method by which they contrasted the performance of children who just "made" and just "missed" the cutoff date established by school districts for admission to the first grade. By doing so, Morrison et al. (1995) compared two groups of children who were essentially the same age - "old kindergarteners" and "young first-graders" - and found evidence that a first-grade experience was particularly important for the development of children's memory skills. Putting these lines of research together, researchers were led to believe that participation in a Western-style school, especially in the first grade, is particularly important for the development of children's memory. But what is it about the early elementary school context that is important?

To address this issue, researchers have carried out extensive observations in elementary school classrooms and had extended conversations with classroom teachers concerning their beliefs and practices regarding memory. Although these conversations suggest that teachers appreciate the importance of fundamental strategic skills such as organizing and rehearsing for children's success in school, they nonetheless report that these skills are not taught in an explicit manner. Classroom observations (see Coffman et al., 2008; Moely et al., 1992) confirm these reports and suggest that even though there is essentially no classroom instruction in specific techniques for remembering, the language that is naturally used by teachers as they teach lessons in specific subject matter domains may nonetheless have an impact on children's developing mnemonic skills.

More specifically, Coffman et al. (2008) observed that when first grade teachers were teaching lessons in language arts and mathematics, instructional language that included references to metacognition and to activities that support deep information processing was associated with gains in children's use of memory strategies such as organized sorting (see also Grammer et al., 2013; Ornstein et al., 2010). To illustrate this language, consider Coffman et al.'s observation that teachers often encourage their students to apply what they already know in the service of the goals of understanding and remembering. They also foster activities that support memory by increasing the depth to which information is processed (e.g., through activities that involve categorization and links to prior experiences). For example, a teacher may begin a lesson by referencing what the class had learned the day before, or could ask the children to, "Make groups of words that have 'long a' versus 'short a' sounds." Moreover, in the context of instruction in mathematics and language arts, teachers often request metacognitive information and make suggestions for strategies that children might use in the service of understanding and learning, such as "*Why did you use that strategy to solve that problem?*"

It thus seems that the language that teachers use during the course of instruction could create a context for strategy discovery and utilization. Perhaps these skills are fostered in terms of the generalization of techniques from one area - say, arithmetic or reading - to remembering. It seems to be the case that natural aspects of teacher instruction contribute to children's strategic endeavors, but understanding specific possible mechanisms underlying children's developing strategic skill requires a deeper understanding of the instruction, and possibly, the teachers' language, that may be implicated.

Linking Teacher Talk to Children's Memory Skills

Building on an extensive literature that highlights the role of maternal language in the development of preschoolers' autobiographical memory skills (see Fivush, Haden, & Reese, 2006), Coffman and her colleagues (2008) sought to understand specific features of teachers' conversational style that is important for children's deliberate strategic memory performance. In order to do so, they developed an observational coding system, the Taxonomy of Teacher Behaviors, for characterizing the degree to which references to remembering and metacognition permeated the classroom. Using the Taxonomy, they developed a measure that was based on five components of teachers' instruction that seemed to be particularly important for characterizing the classroom. They found that teachers differed in the extent to which their language while teaching mathematics and language arts was characterized by (a) strategy suggestions, (b) metacognitive questioning, (c) the co-occurrence of memory requests with (i) instructional activities, (ii) cognitive structuring activities that increase the depth to which information is processed, and (iii) metacognitive information. Using these codes, a measure of teachers' use of *Cognitive Processing Language*, or CPL¹, was created.

Using this observational system, Coffman and her colleagues (Coffman et al., 2008; Grammer et al., 2013; Ornstein, Grammer, & Coffman, 2010) demonstrated the importance

¹CPL was previously termed "Mnemonic Style" (Coffman et al., 2008).

of teachers' language for understanding children's memory performance. Importantly, Coffman et al. (2008) found that children taught by first grade teachers who incorporate higher levels of CPL into their teaching evidence better skill in the use of deliberate strategies for remembering than did their peers who were taught by teachers who use lower levels of CPL. For example, consider the students' performance on a Free Recall with Organizational Training task (Moely et al., 1992) in which they were able to form groups of categorically-related pictures prior to being asked to report what they could remember. At the first assessment point in the fall of Grade 1, each child received three trials - baseline, training, and generalization - whereas at later assessments in the winter and spring, only non-instructed generalization trials were administered. The sorting performance of the children who were drawn from classrooms that were higher versus lower in the amount of CPL used by the teacher did not differ initially on either the baseline or generalization trials at the first assessment point (Time 1) of Grade 1, but by the winter, the groups had diverged, with differences evident at both Time 2 and Time 3.

Following up this correlational finding, Grammer et al. (2013) carried out an experimental project in after-school programs in local schools in an attempt to identify causal linkages between teacher style and children's performance. In this study, first and second graders took part in a two-week science and engineering unit involving Things that Move and were assigned to one of two instructional conditions that varied only in their teachers' use of memory-relevant language. Although the activities and material covered in the lessons were the same for all participants, the language used by the teachers to present the content was modeled on the two contrasting styles documented by Coffman et al. (2008). Interestingly, although all participating children learned new factual information about Things that Move as a result of instruction, those exposed to more CPL during lessons acquired more strategic knowledge. Importantly, they were also better able to apply this knowledge in the service of a memory goal than were the children who received lower levels of CPL. These differences were observed in their enhanced meaning-based sorting performance when presented with a memory task based on the materials (e.g., beams, gears) to which they were exposed in the instructional unit.

This combination of longitudinal and experimental evidence suggests that aspects of teacher language in the classroom indeed important for the development of early elementary students' basic strategic skills. However, questions remain concerning whether teacher language in the classroom are indeed important for the development of early elementary students' basic strategic skills. However, questions remain concerning whether teacher language in the early elementary school years that is rich in references to metacognition, cognitive processes, and requests for remembering continues to be important for the consolidation of children's skills and the emergence of more sophisticated strategies. It also remains to be seen if this language is important for the emergence of skills for studying academic material in specific instructional domains. Clearly, as children progress from elementary school and into middle and high school, it becomes increasingly important that they begin to interact strategically with material that is covered in content areas such as science and social studies. Recently there has been growing interest in the most effective ways of studying (for subsequent remembering and application) among high school and college students (e.g., Bjork, Dunloskly, & Kornell, 2013), but little is known about the ways

in which children acquire and hone their skills for independent studying. However, it has long been hypothesized that the development of these skills across late and middle school builds on the development of skills observed on memory recall tasks (Brown, Bransford, Ferrera, & Campione, 1983).

In the research that we present here, we seek to examine (1) linkages between early basic skills as observed in the first grade and later-emerging more complex techniques as seen in the second and fourth grades, and (2) the extent to which exposure to instructional language in first grade classrooms that is rich in references to metacognition, cognitive processes, and memory requests is important for these developmental changes. Our focus on the first-grade context allows for the evaluation of long-term associations between classroom instruction and children's performance across the elementary school years, linkages that are hypothesized to exist even though children may later be exposed to teachers with different instructional styles. We recognize that the experiences of children in each grade of elementary school matter, but the random assignment of children to classes (and hence the instructional styles of their teachers) allows us to focus here on the critical first grade experience. In our presentation of our work, we will also document the ways in which our research agenda has been shaped by our partnership between researchers and educators.

Method

In the longitudinal study that provides the foundation for this report, an initial sample of 107 first-graders was established, and the children were assessed across the first-, second-, and fourth-grade years, while observations were made of their teachers' use of CPL during instruction. A multi-task battery was used to assess the participants' memory performance multiple times, so as to examine factors associated with the use of memory strategies and the emergence of school-related study skills. In this report, we will focus on a subsample of 58 children who completed all assessments over the first through fourth grades. Specifically, we examine their use of an organizational strategy (sorting at input) on a Free Recall with Training task (Moely et al., 1992), as well as their later use of a sorting strategy on a more complex Sort-Recall task (Corsale & Ornstein, 1980) and their performance on a Study Skills task (Brown & Smiley, 1977, 1978). In each of these tasks, an index of strategic behaviors was obtained. A backwards digit span (McCarthy, 1972) task was also included to assess children's working memory capacity.

Participants

The sample of 15 teachers and 107 children were recruited from 14 first grade classrooms across 2 southeastern school districts. Participating teachers were told that the purpose of the study was to examine the classroom context and its influence on children's cognitive skills. All teachers agreed to be observed as they taught regularly-occurring lessons in language arts and mathematics. The teachers were female and an average of 36-years-old (range = 23–51). Eighty percent of teachers were Caucasian and 20% were African American. Teachers had a mean of 10.6 years (range = 1–30) teaching experience, with an average of 7.5 years (range = 1–30) of teaching first-grade students.

Families with children in participating classrooms received a letter and all children who returned the consent form were enrolled in the study with no criteria for exclusion. Of the initial participants, a subgroup of 58 children completed all assessments across the first-, second-, and fourth-grade years (34 female, 24 male), and are the focus of the analyses presented here². Children's mean age was 79 months (6;7) (range = 71–88 m) at the start of the study. The diversity of the sample was representative of the 2 school districts from which the participants were drawn. Fifty-nine percent of the families described their ethnicity as Caucasian, 22% as African-American, 2% as Hispanic/Latino, 12% as Asian, and 5% as being of mixed ethnicity.

Procedures

Child Assessments.—Initial assessments of the children were conducted during the fall of their first-grade year. Subsequent assessments occurred during the early spring of children's first-, second-, and fourth-grade years. The tasks included in the assessment battery enable the characterization of the children's changing abilities to deploy strategies in the service of remembering. The Free Recall with Training and the Sort-Recall tasks tap the children's use of organizational techniques that are known to be related to success at remembering sets of pictures and words, basic skills that teachers suggest are related to adaptation to the demands of the classroom. The Study Skills task taps "higher order" study skills that are involved in understanding and remembering information presented in texts, such as those used in the later elementary school year. Further, working memory is included as a measure of basic capacity that may impact children's abilities to take advantage of the rich language environment of the classroom. Inclusion of a working memory task enables us to be certain both that the children in classrooms in which the teachers differ in their use of CPL do not differ in terms of this basic measure of cognitive ability, and also that measures of children's strategy use tap more than merely basic cognitive skills. All of these tasks were administered by trained research assistants who conducted assessments with children at their respective schools. The assessments were videotaped for later processing and coding.

Free Recall with Training (Moely et al., 1992).: As part of children's first-, and second-grade assessments, each child was presented with a set of 16 cards containing line drawings of objects drawn from four conceptual categories. The strength of association between items in a conceptual category varied as a function of children's grade level, such that first graders were presented with more closely related items (i.e., fruits, animals, transportation groups) than second graders (i.e., space or fairytale-themed items). Items were displayed one at a time in a random order and left visible in order for children to "work to remember" the items for as long as needed. At the first assessment point in the fall of grade 1, each child received three trials - baseline, training, and generalization - whereas in the spring of grade 1 and the spring of grade 2, only non-instructed generalization trials were administered. In the baseline trial, no explicit instructions for strategy use were given so that children's spontaneous use of organizational techniques could be observed. In the training trial, children were told that if they put the cards into groups (e.g., fruit, transportation categories)

²The performance of these 58 children on all measures included in the assessment battery in the fall of the first grade was comparable to that of the children who did not complete the study.

that they will remember better. The generalization trial was with a new set of stimulus cards and contained no strategy instruction. To characterize children's sorting during the study period, a standard index of categorical grouping, the adjusted ratio of clustering (ARC) score, was calculated (Roenker, Thompson, & Brown, 1971). The ARC scores ranged from -1 (below chance organization) to 0 (chance) to 1 (complete organization). Two research assistants independently scored all records. Discrepancies were resolved through the examination of the original video recordings.

Sort Recall (Corsale & Ornstein, 1980).: During the fourth-grade assessment, each child was presented with 20-low associated nouns and was asked to form groups with the items that would help him or her remember during a 3-minute study period. By using materials that did not have salient inter-item connections, it was possible to explore the extent to which the children sought out and imposed their own organization on the items. Immediately following, recall was assessed and sorting patterns were recorded. Two coders subsequently rated each trial in terms of the level of semantic organization observed on each sort. Scores ranged from 0 (random with no apparent order) to 4 (cohesive with few items not sorted into meaningful groups). All discrepancies were resolved through discussion.

Study Skills (Brown & Smiley, 1977,1978).: As part of the fourth-grade assessment, each child was presented with a brief passage obtained from grade appropriate science and/or social studies texts. They were first asked to read the passage while following along with an audio recording of the text. Children were provided with a four-minute study session and were asked to "work to remember" the passage. A pencil, highlighter, notepad, and dictionary were provided as aids, but children were not provided with explicit encouragement to use the materials. Immediately following, open-ended recall was assessed and children both verbally recalled as much information as they could from the passage (measured in meaningful units of content) and described their study strategies in response to an open-ended prompt. Children's strategy nominations, as well as their behaviors, were used to determine what study techniques were used. Two coders scored children's strategic behaviors, including note taking, text underlining, highlighting, reviewing notes, drawing a picture, using the dictionary, rereading, and self-testing on a scale ranging from 1 (poor implementation of a strategy, e.g., taking notes by copying the passage in rote) to 3 (very organized, efficient use of a strategy; e.g., taking notes on only key facts, summarizing, and/or providing and outline of the text), with discrepancies resolved through discussion. Unobserved strategies were not scored. Of the study strategies, the scores for those observed were averaged for an overall score reflecting children's strategy use.

Working Memory (McCarthy, 1972).: In the fall of the first grade, a backward version of the digit span task was administered following standardized assessment procedures. Each child was asked to repeat a presented string of numbers in a backward order. Presented strings began with two numbers and increased in length with each additional trial. When a child incorrectly responded, another string of the same length was administered. The task was discontinued after two incorrect responses within the same span length. Children's spans represent the longest string of digits correctly recalled. Two coders scored children's

recall and all discrepancies were resolved through the examination of the original video recordings.

Classroom Observations.: Extensive observations were made in the first-grade classrooms of the participating children, so as to allow for an assessment of the associations between children's early school experience and their strategic skills over time. Using methods employed previously (see Coffman et al., 2008; Grammer, Coffman, Sydney, & Ornstein, 2016; Hudson, Coffman & Ornstein, 2017), observations were carried out in each of the participating first-grade classrooms in order to characterize teachers' Cognitive Processing Language (CPL; previously termed Mnemonic Style). Teacher-led whole-group instruction was observed in each of the classrooms during regularly scheduled lessons in language arts and mathematics. For each teacher, observations were made during a total of 240 30-second intervals, or 120 minutes of instruction, with 60 minutes each in language arts and mathematics. The lessons in these areas were often substantially less than a half hour in duration, and it took multiple trips to each classroom to accumulate the necessary time; lessons were included when a teacher had nominated that a lesson was intended and the researchers observed instruction in the content domain. Lessons ranged from 3 to 30 minutes of teacher-led instruction, and it took from two to seven visits per teacher to collect 60 minutes of instruction in each subject area.

Trained observers used the Taxonomy of Teacher Behaviors coding system (Coffman et al. 2008) to make decisions every 30 seconds about the nature of a teacher's use of CPL. With this measure, teachers' language is described based on the nature of naturalistic classroom instruction regarding metacognitive awareness, remembering, and cognitive processing information and strategies. The Taxonomy is based on classifying teachers' discourse while teaching into the four broad categories of instruction, cognitive structuring activities, memory requests, and metacognitive information. Each of these four categories is composed of a set of individual codes that permit a fine-grained analysis of instruction in the classroom, and we focus here on a subset of five component codes that have previously been used to characterize the language of the teachers in each classroom (Coffman et al., 2008). These five component codes are described in Table 1: (1) *strategy suggestions*, (2) *metacognitive questioning*, (3) *the co-occurrence of deliberate memory demands and instructional activities*, (4) *the co-occurrence of deliberate memory demands and cognitive structuring activities*, and (5) *the co-occurrence of deliberate memory demands and metacognitive information*.

A set of videotaped lessons was used to train the classroom observers in the use of the Taxonomy system in advance of observing instruction in the classroom setting to reach reliability before conducting coding live in the classroom. To this end, each observer coded 50 30-second intervals with the Taxonomy, and the performance of the observers was then compared with that of a master coder, with each observer being required to attain a criterion of at least 80% reliability prior to the start of data collection. The Taxonomy reliability scores ranged from 80% to 96%, with an average of 87%.

Results

In the sections that follow, we first describe children's strategic development over time by examining early use of organizational strategies on a Free Recall Task (Moely et al., 1992) in first grade and second grade, as well as the later use of a sorting strategy on a more complex Sort Recall Task (Corsale & Ornstein, 1980) in fourth grade. We then examine children's performance on a Study Skills task (Brown & Smiley, 1977) in fourth grade in relation to their earlier use of organizational strategies. Finally, we consider variation in the use of Cognitive Processing Language (CPL) among first grade teachers and explore the longitudinal linkages between children's strategy use, study skills, and the types of language to which they are exposed in first grade.

Statistical Analyses

Analyses were carried out in StataSE 14. A series of multiple regressions were fit using Huber-White sandwich estimators to account for the fact that children were nested within classrooms (Huber, 1967; White, 1980). This approach yields unbiased standard errors for cluster-correlated data.

Describing Children's Strategy Use and Study Skills

Data are first presented descriptively in order to (1) characterize changes at the group level across first, second, and fourth grades, and (2) examine associations between early and later strategy use as well as both longitudinal and concurrent relations between children's strategy use and study skills. In addition, these data provide a foundation for the regression models that enable the exploration of the variability in children's strategy use and study skills as a function of teachers' use of CPL. The overall sample means on measures of working memory, strategy use, and study skills are presented in Table 2. The results of the backward version of the Digit Span Task, an indicator of children's working memory, are displayed in the top portion of Table 2. On average, children were able to recall approximately three numbers in backwards order in first grade ($M = 3.37$, $SD = .93$) and approximately four numbers in backwards order in second grade ($M = 3.95$, $SD = 1.07$) and fourth grade ($M = 4.53$, $SD = 1.06$).

Children's use of organized sorting on the Free Recall Task (Moely et al., 1992), as assessed by the Adjusted Ratio of Clustering (ARC) measure (Roenker et al., 1971) is also presented in Table 2. The ARC scores could range from -1 (below chance organization), to 0 (chance), to 1 (complete categorization). As can be seen in Table 2, in the fall of the first-grade year the average ARC score on the baseline trial indicated chance-level grouping ($M = -.02$, $SD = .44$). Following training in the use of an organizational strategy, children's performance on a generalization trial improved ($M = .58$, $SD = .56$; $t(53) = -6.76, p < .01$). Children's use of organized sorting continued to increase into the spring of first grade ($M = .70$, $SD = .48$) and was comparable in the spring of second grade ($M = .64$, $SD = .50$), even when the semantic associations among the items in the categories were less strong than the materials in the first grade. Children's sorting during the generalization trial in the fall of the first grade was statistically significantly associated with their performance in the spring of the first grade ($r = .29$, $p < .05$) as well as the spring of the second grade ($r = .37$, $p < .01$). Moreover,

children's sorting scores in the spring of first grade were strongly correlated with their sorting scores in the spring of second grade ($r = .54, p < .01$)

In the spring of fourth grade the children completed a more complex Sort Recall Task and a Study Skills Task. On this more complex sorting task, the children received an average sort score of 2.16 ($SD = 1.17$) on the organizational scale from 0 (random sorting) to 4 (clear semantic associations), which corresponds to a moderate level of organization in the spring of fourth grade. Children's earlier strategy use as assessed by the ARC measure on a Free Recall with Training Task was associated with children's later strategy use on the more complex Sort Recall Task. As can be seen in Table 3, children's sorting scores in the spring of first grade were moderately correlated with their sorting scores in the spring of fourth grade ($r = .35, p < .01$).

In addition to completing the Sort Recall Task, children also completed a Study Skills Task in the spring of fourth grade. The mean overall strategy score was 1.97 (range 1–3, $SD = .55$) indicating that, on average, the children made use of some strategic behaviors but they were not particularly organized or efficient. Concurrent associations were found between the children's strategic behavior in the Study Skills Task and their use of organizational strategies on the Sort Recall Task in fourth grade ($r = .30, p < .05$). Moreover, longitudinal associations were observed between children's strategic behavior in the Study Skills Task in fourth grade and children's use of organizational strategies in the Free Recall Task in the spring of the first ($r = .29, p < .05$) and second ($r = .31, p < .05$) grades.

Characterizing Teachers' Cognitive Processing Language

In parallel with the assessments of the children's memory performance, teacher-led instruction was observed and measured in terms of the numbers of 30-second intervals (out of a total of 3,360) in which the different behaviors included in the observational coding system were recorded. The data reported in Table 4 characterize the language used by the teachers in the course of 120 minutes of instruction in terms of the five critical codes that contribute to the measurement of CPL. Inspection of the table indicates the percentage of the 120 30-second intervals of teaching in which the behaviors defined by each of the codes were observed. To illustrate, as can be seen in the left column of Table 4, an average of 4.9% of the intervals contained strategy suggestions, whereas 37.6% of the intervals included both deliberate requests for remembering and instructional activities. It should also be noted that for each of the codes there was considerable variability across classrooms. For example, one of the first-grade teachers almost never made a strategy suggestion (0.8%), whereas another included such suggestions in 13.8% of the observed intervals. Interestingly, substantial differences across the classrooms were also seen in the coding of joint behaviors such as deliberate memory demands and either cognitive structuring activities (ranging from 10.0% to 35.4%) or metacognitive information (ranging from 1.3% to 12.1%).

Because of the clear variability in the rates of occurrence of these different behaviors, it was necessary to compute standard scores so that the values could be combined into a composite measure. Accordingly, each code was standardized on the basis of its mean and standard deviation so that the teachers could be assigned T-scores for each of the five codes. The T-scores across these measures were then averaged to yield a measure of CPL that could be

used to contrast the different classrooms. Although the teachers' CPL scores varied continuously, for purposes of analysis we assigned them to two groups - high versus low in the inclusion of CPL during instruction - on the basis of a median split based on the overall percent occurrence. Thus, 7 classrooms were classified as being high and 7 as low in their use of CPL. It is important to note that these groups of teachers did not differ in terms of potentially confounding variables such as education level or teaching experience and that teachers with relatively high vs. low use of CPL were evenly distributed across schools and the school districts in which data collection occurred. Indeed, the two groups of teachers who employed contrasting levels of CPL were similar on a range of demographic characteristics, including age (34.9 years versus 37.7 years, for the low and high groups respectively), years of overall teaching experience (9.21 years versus 11.38 years), and years of teaching in the first grade (7.57 years versus 7.38 years), $t_s(13) \leq .53$, $p_s \geq .61$. The two groups were also similar in terms of their educational levels, with three teachers in the low CPL group and two in the high CPL group having Master's degrees.

Linking Teachers' Language to Children's Strategy Use

We next examined the extent to which first-grade teachers' use of CPL during instruction was associated with variation in children's strategy use in the first-, second, and fourth grades, using multiple regression analyses to examine strategy use as a function of first-grade teachers' CPL. By using Huber-White sandwich estimators, these analyses accounted for the nesting of the children in the individual classrooms. In order to control for initial sorting behaviors, children's strategy use at the beginning of first grade was also included as a covariate in second and fourth grade analyses³.

Two multiple regression analyses were conducted to examine the extent to which children's organized sorting on a Free Recall Task (Moely et al., 1992) in first grade was related to teachers' use of CPL. At the beginning of first grade, the overall model was not statistically significant, $F(1, 52) = .15$, $p = .70$, indicating, as expected, that teachers' CPL was not associated with children's strategy use at the beginning of the year. The results from this analysis are displayed in Table 5 and Figure 1. As can be seen on the left side of the figure, at the beginning of first grade there was no difference in children's use of organized sorting as a function of teachers' use of CPL. Children whose teachers used CPL more frequently performed similarly ($M = -.04$, $SD = .41$) to their peers whose teachers provided less CPL during instruction ($M = .01$, $SD = .48$).

However, by the spring of first grade, when controlling for children's initial (fall) performance, the overall model was significant, $F(2, 51) = 5.96$, $p = .01$, demonstrating that the children whose teachers used higher levels of CPL engaged in more strategic sorting ($M = .84$, $SD = .35$) than their peers whose teachers provided less CPL during instruction ($M = .51$, $SD = .57$). As shown in Table 6, this reflects a moderate effect size between teachers' use of CPL and children's strategy use at the end of first grade (standardized regression coefficient = .28, $p = .05$).

³Children's performance on the backward series digit span were initially included in the model building process to control for differences in children working memory skills. Children's working memory skills did not significantly contribute to any of the models predicting children's sorting or study skills and thus is not included in the final models presented.

Two additional multiple regression analyses were conducted to examine the extent to which first-grade teachers' use of CPL continued to influence children's strategic sorting behaviors in second and fourth grade. These analyses included children's initial sorting behaviors in the fall of first grade as covariates. As presented in the third set of bars in Figure 1, those children who experienced greater amounts of CPL during first grade engaged in more semantically-based organized sorting in the spring of second grade ($M = .74$, $SD = .43$) than their peers who experienced less CPL during first grade ($M = .50$, $SD = .55$). The overall model was statistically significant, $F(2, 51) = 4.29$, $p = .02$ and indicated that teachers' CPL was a moderate predictor of children's organized sorting in second grade (standardized regression coefficient = $.27$, $p = .05$). Results from this analysis are displayed in Table 7.

A similar pattern was observed in fourth grade, such that first grade teachers' use of CPL continued to be associated with children's use of organizational sorting on the Sort Recall Task in the spring of the fourth grade. As displayed in the far right bars in Figure 1 and in Table 8, those children who experienced greater amounts of CPL during first grade continued to engage in more organized sorting ($M = 2.47$, $SD = 1.08$) than their peers who experienced less CPL during first grade ($M = 1.71$, $SD = 1.16$). The overall model was statistically significant $F(2, 51) = 3.42$, $p = .04$ and indicated that first grade teachers' use of CPL was a moderate predictor of children's organized sorting in fourth grade (standardized regression coefficient = $.33$, $p = .02$).

Linking Teachers' Language to Study Skills

A final multiple regression analysis was conducted to examine the effect of exposure to CPL on children's study skills in fourth grade. In the spring of fourth grade, as illustrated in Figure 2, those children who experienced greater amounts of CPL in first grade engaged in more frequent use of study skills ($M = 2.11$, $SD = .47$) than their peers who were exposed to less CPL in first grade ($M = 1.78$, $SD = .59$). After controlling for children's initial strategy use at the beginning of first grade, the overall model was statistically significant $F(2, 50) = 5.34$, $p = .01$ and indicated that first grade teachers' use of CPL was a moderate predictor of children's study skills in fourth grade (standardized regression coefficient = $.27$, $p = .05$), as can be seen in Table 9.

Discussion

In this report we extend previous work on children's memory and study skills by (1) examining children's performance across elementary school and (2) considering the long-term importance of the instructional language to which children are exposed to in first grade. These findings also permit us to discuss the evolution of our research program and the ways in which it has been impacted by continued discussion with educators.

First, associations were observed between children's meaningful sorting in the first grade and their growing strategic skills in the second and fourth grades. Not only were linkages observed between the children's use of a sorting strategy with salient categorical material in the first grade and their use of a similar strategy with less salient thematic material in the second grade, but similar relations were also observed with the children's performance in the fourth grade with more difficult low-associated items. Clearly, the children acquired a

meaning-based approach to grouping in tasks that call for deliberate remembering that they were able to transfer to more demanding tasks. In addition, linkages between children's early sorting and their later use of study skills in fourth grades were observed. These findings provide preliminary evidence to support the claim that more complex strategies have their roots in children's early strategic efforts.

Second, the associations previously observed between first-grade teachers' use of language that is rich in reference to metacognition, cognitive processes, and remembering (i.e., higher levels of CPL) during instruction and their students' use of strategies for remembering (Coffman et al., 2008) have been extended in several important ways. Moving beyond the earlier finding that teachers' use of CPL in the first grade is linked to children's organized sorting at the end of the first grade, it is now known that teachers' language is linked to the children's sorting in different tasks in the second and fourth grades, when they are taught by different teachers. Similarly, there were long-lasting associations between first-grade teachers' use of CPL and children's use of academic study skills in the fourth grade. Thus, although children's memory strategy use improves greatly across the early grades in general, there seems to be something unique about the first-grade classroom context that is important for the development of these skills.

From the perspective of basic developmental and cognitive science in which our research program has been embedded, the findings - particularly, when taken together with experimental findings (e.g., Grammer et al., 2013) in which teachers' instructional language has been manipulated - enable us to view the classroom language environment as playing an important role in children's developing memory and study skills. Moreover, when viewed in the context of extended conversations with teachers and school administrators, we are led to think collaboratively about a new phase of this research program in which our work may have tangible benefits for teachers' instruction and children's learning. Extended discussions among researchers, teachers, and school administrators have already impacted the ways in which we think about individual differences among both teachers and children. For example, we are focusing considerable attention on differences among teachers in the extent to which they "naturally" include high levels of CPL in their instruction and on the differences in their informal "theories of instruction" that are associated with their practice. We are also examining differences among characteristics of young children (e.g., their basic self-regulation skills) that may make exposure to high levels of CPL particularly important for their skills and development. In these ways, the partnership between researchers and school personnel has informed the basic research program, and set the stage for future applied applications in the classroom that have the potential to impact teaching and learning.

A natural next step has been to discuss ways of mounting "interventions" through professional development workshops in which in-service teachers are given opportunities to increase the extent to which they can incorporate high levels of CPL into their classroom instruction. In fact, with the support of the schools, we have carried out some small-scale training studies, designed in part on the basis of extended discussions with classroom teachers, as they have reacted to presentations of both the basic literature and reports of our previous studies in brief workshops. The results of these pilot studies have been encouraging in terms of teachers' increased use of CPL, but fuller-scale interventions are certainly

needed to both strengthen the causal inferences that we can make about the associations that we observe and to increase the ways in which research-based data can be used by educators to meet the needs of their students. Our aim is to work toward a more complete intervention based on additional discussion with educators of our latest findings on individual differences and a consideration of current work in developmental and cognitive science. The cornerstone of these efforts is the continued interpretation and input of the teachers and administrators regarding the existing findings, along with their knowledge of what it will take to continue to work in the school context.

As we move forward, the next phase of our research will involve instruction in the use of CPL in the context of the professional development activities of the school districts in which we work. Teachers and administrators have already told us that one of the strengths of our interventions is that training in the use of CPL does not require the learning of a new curriculum, as it instead involves emphasizing the use of language that can be applied broadly across domains of instruction or texts that are being used. We will build on teacher enthusiasm for CPL in the ways in which we implement instruction in the context of professional development workshops, taking care to heed the suggestions of the school systems with regard to additional measures of student-, family- or school-level variables that may be important for the associations that we see between teacher instruction and children's academic outcomes, and certainly making use of their input regarding the feasibility of scaling up our intervention efforts. For example, in moving forward the research team must rely on our educator colleagues for information concerning district-wide curriculum or program fluctuations that may require us to modify a key aspect of the training that we provide.

Moving beyond the development of interventions, collaboration between researchers and educators yields other benefits. For example, changes in curricula and programs at the system level may have implications for interpreting cohort differences, if any are detected in either teacher or child performance. In addition, integrating observations of teachers' use of CPL and student performance on our measures with the administrative and achievement data from participating districts may allow for a more thorough examination of both children's developing skills and the role of the classroom context in these changing abilities. Based on our collaborative experiences, we are confident that working at the intersection of cognitive and developmental science, on the one hand, and educational practice, on the other can enable interdisciplinary teams to advance basic research questions that also have strong implications for teachers' instruction and students' learning.

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Figure 1:

Sorting ARC Scores across Elementary School as a Function of First-Grade Teachers' CPL

Note. * $p < .05$.

Figure 2:
Strategic Behaviors on the Study Skills Task in 4th Grade as a Function of First-Grade Teachers' CPL

Note. * $p < .05$

Table 1

Component Codes from the Taxonomy Used to Index Cognitive Processing Language (adapted from Coffman et al., 2008)

Code	Definition	Example
Strategy Suggestion	Recommending that a child adopt a method or procedure for remembering or processing information	"If that doesn't make sense, go back and reread or look at the picture."
Metacognitive Question	Requesting that a child provide a potential strategy, a utilized strategy, or rationale for a strategy they have indicated using	"What are some strategies you could use to help you figure that out?"
Co-occurrence of Deliberate Memory and Instructional Activities	Requesting information from children's memory while also presenting instructional information	"Today we are going to write a story about our field trip to the zoo. What was the first thing we did when we got there? Remember, a story has a beginning, middle, and end."
Co-occurrence of Deliberate Memory and Cognitive Structuring Activities	Requesting information from children's memory while simultaneously facilitating encoding and processing by focusing attention or organizing material	"Yesterday we talked about states of matter. What are the three forms that water can take?"
Co-occurrence of Deliberate Memory and Metacognitive Information	Requesting information from children's memory while providing or soliciting metacognitive information	"How many seashells are there in all? How did you solve that problem? How did you know that you should add?"

Table 2

Summary of Child-level Performance

	1 st Grade				2 nd Grade		4 th Grade	
	Fall		Spring		Spring		Spring	
	Mean (<i>SD</i>)	Range	Mean (<i>SD</i>)	Range	Mean (<i>SD</i>)	Range	Mean (<i>SD</i>)	Range
Digit Span								
Working Memory	-	-	3.37 (.93)	0–6	3.95 (1.07)	2–6	4.53 (1.06)	3–6
Free Recall Task								
Baseline ARC Score	-.02 (.44)	-.23 – 1	.70 (.48)	-.23 – 1	.64 (.50)	-1 – 1	-	-
Generalization ARC Score	.58 (.56)	0–1						
Sort Recall Task								
Strategy Use	-	-	-	-	-	-	2.16 (1.17)	0–4
Study Skills Task	-	-						
Study Skills	-	-	-	-	-	-	1.97 (.55)	0–3

Table 3

Summary of Correlations

		1	2	3	4	5	6
1.	Grade 1 Fall Baseline Sorting	–					
2.	Grade 1 Fall Generalization Sorting	.21	–				
3.	Grade 1 Spring Sorting	.24	.29 *	–			
4.	Grade 2 Sorting	.25	.37 *	.54 **	–		
5.	Grade 4 Sorting	.11	.19	.35 **	.17	–	
6.	Grade 4 Study Strategies	.34 *	.05	.29 *	.31 *	.33 *	–

*
 $p < .05$

**
 $p < .001$

Table 4

Percent Occurrences of Teacher Behaviors

	<u>Grade 1</u>		
	Overall	Language Arts	Mathematics
<i>Taxonomy Codes</i>			
Strategy Suggestions	4.9% (0.8%–13.8%)	3.2% (0.0%–13.3%)	6.7% (0.0%–16.7%)
Metacognitive Questions	4.9% (0.8%–9.6%)	2.7% (0.0%–14.2%)	7.1% (0.0%–16.7%)
<i>Co-occurrence of Deliberate Demand with:</i>			
Instructional Activities	37.6% (25.8%–50.0%)	35.2% (21.7%–49.2%)	40.2% (25.8%–58.3%)
Cognitive Structuring	23.5% (10.0%–35.4%)	23.7% (9.2%–39.2%)	23.2% (8.3%–36.7%)
Metacognitive Information	5.9% (1.3%–12.1%)	2.9% (0.0%–10.8%)	8.9% (0.0%–21.7%)

Table 5Summary of Multiple Regression Analyses for Strategy Use in the Fall of 1st Grade

Measure	β	Robust <i>SE</i>	<i>t</i>	<i>p</i>
Teacher Cognitive Processing Language	-.06	.13	-.39	.699

Table 6Summary of Multiple Regression Analyses for Strategy Use in the Spring of 1st Grade

Measure	β	Robust <i>SE</i>	<i>t</i>	<i>p</i>
Strategy Use at Time 1	.26	.08	3.37	.001 **
Teacher Cognitive Processing Language	.28	.13	1.96	.055 *

Note.

*
 $p < .05$.**
 $p < .01$

Table 7Summary of Multiple Regression Analyses for Strategy Use in the Spring of 2nd Grade

Measure	β	Robust <i>SE</i>	<i>t</i>	<i>p</i>
Strategy Use at Time 1	.26	.11	2.67	.010 **
Teacher Cognitive Processing Language	.27	.13	1.99	.051 *

Note.

*
 $p < .05$.**
 $p < .01$.

Table 8Summary of Multiple Regression Analyses for Strategy Use in the Spring of 4th Grade

Measure	β	Robust <i>SE</i>	<i>t</i>	<i>p</i>
Strategy Use at Time 1	.13	.35	1.00	.321
Teacher Cognitive Processing Language	.33	.32	2.50	.016 *

Note.

*
 $p < .05$.

Table 9Summary of Multiple Regression Analyses for Study Skills in the Spring of 4th Grade

Measure	β	Robust <i>SE</i>	<i>t</i>	<i>p</i>
Strategy Use at Time 1	.35	.13	3.10	.003 **
Teacher Cognitive Processing Language	.27	.14	2.02	.049 *

Note.

*
 $p < .05$.**
 $p < .01$.