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COGNITIVE DEVELOPMENT

Cognitive Development 19 (2004) 417–431

Task demands and knowledge influence how children learn to read words

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Received 1 October 2003; received in revised form 1 April 2004; accepted 1 May 2004

Abstract

To examine how young children learn to read new words, we asked preschoolers ($N = 115$, mean age 4 years, 8 months) to learn and remember novel spellings that made sense based on letter names (e.g. TZ for *tease*) and spellings that were visually distinctive but phonetically inappropriate. Children who were more knowledgeable about letter names tended to perform better in the name condition than the visual condition. In contrast, prereaders with little knowledge of letter names performed better in the visual condition than the name condition. Increasing the difficulty of the task led to more advanced patterns of performance, in that a benefit for the name condition over the visual condition was more likely to emerge when children learned five items at a time than when they learned four. This result, which is the opposite of that typically found in the literature on strategy development, appears to arise because the demands of learning a larger set of words encourage an analytic, letter-based approach.

Keywords: Reading; Letter names; Strategies; Printed word learning; Task demands

The typical preschool child knows thousands of spoken words but few, if any, printed words. Within a few years, that child will be expected to learn and remember a large number of printed words. This task may be approached in two ways. One method involves the use of letter–sound relationships to remember the identities of printed words. A second possible approach is non-alphabetic. For example, a child might remember *yellow* by virtue of the two “sticks” in the middle. Such a child will misread *balloon* and *follow*, however, showing

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0885-2014/$ – see front matter
doi:10.1016/j.cogdev.2004.05.001

some of the disadvantages of a non-alphabetic strategy. Theories of reading acquisition often portray the non-alphabetic approach as developing first, followed later by the alphabetic method (e.g. Frith, 1985; Gough & Hillinger, 1980).

Although stage theories have been popular in the field of reading development, researchers in cognitive development more generally have moved away from stage theories and toward the view that change is more gradual. For example, Siegler's (1996) overlapping waves model depicts children as possessing multiple strategies at each point in time and choosing among these strategies in a flexible manner. Most of the evidence for the overlapping waves view comes from such domains as arithmetic (e.g. Siegler & Shrager, 1984) and conservation of number (e.g. Siegler, 1995). Rittle-Johnson and Siegler (1999) applied the overlapping waves model to one aspect of literacy development, spelling. Their results suggested that first and second graders employ a variety of strategies in spelling and that children choose adaptively among strategies based on the difficulty of the word.

The present study was designed to explore issues of multiple strategies and strategy choice in reading, looking at children younger than those studied by Rittle-Johnson and Siegler (1999). We used the word-learning task that was introduced by Ehri and Wilce (1985). In their study, U.S. children averaging 5 years, 7 months in age were taught to pronounce sets of novel words. The phonetic set contained items such as SZRS for *scissors* and MSK for *mask*. The letters in these spellings corresponded to sounds in the words' pronunciations. In the visual set, the letters in the spellings did not map onto the expected sounds in the words' pronunciations. The letters varied in size and position and no letter was repeated within a set, making the spellings more visually distinctive than those of the phonetic condition. For example, *scissors* was spelled as QD$_J$K and *mask* was spelled as UH$_E$ in the visual condition. Each child learned to read one set of words in the phonetic condition and another set of words in the visual condition. Children who were not yet able to read real words showed more rapid learning in the visual condition than the phonetic condition. In contrast, children who could read even a few simple words did better in the phonetic condition than the visual condition. These results support the idea that developing readers move from a period marked by reliance on visual cues to a phase in which they are able to use phonetic information.

Although the results of Ehri and Wilce (1985) suggest that prereaders do not benefit from systematic relationships between letters in spellings and sounds in pronunciations, later studies have found that U.S. prereaders can take advantage of some such relationships—those that capitalize on initial-position letter names (Treiman & Rodriguez, 1999; Treiman, Sotak, & Bowman, 2001). Three sets of items were used in these studies. In one set, the entire name of each word's first letter was heard in its pronunciation. For example, BT was presented as a spelling for *beet*. In a second condition, the cues involved the sounds of the initial letters, as when BT was pronounced as *bait*. This pronunciation includes the phoneme /b/, but not the entire name of the letter *b*. The sound condition was thus similar to the phonetic condition of Ehri and Wilce. In the third condition, the relationships between print and speech did not make sense on the basis of either letter names or letter sounds but the stimuli offered distinctive visual cues, as when BT was presented as a spelling for *ham*. This condition was modeled after the visual condition of Ehri and Wilce. Prereaders (mean ages: 5 years, 0 months in Treiman & Rodriguez; 4 years, 3 months in Treiman et al.) performed significantly better in the name condition than in the sound or visual conditions.

These children were unable to read simple words like *the* and *stop*, but they did know some letter names. The results suggest that young children use their knowledge of letter names—knowledge that typically develops at an early age among U.S. children—to make preliminary connections between print and speech, at least when those connections are in the salient initial positions of words (Bowman & Treiman, 2002).

The present study was designed to examine how children's strategies for learning to pronounce novel printed items are influenced by their knowledge of reading and letters and by the demands of the task. In the literature on cognitive development, knowledge has been identified as one factor that is important for strategy use. Evidence comes from studies of children's ability to remember lists of words. One helpful method is to organize the words into categories and recall the words in each category. Children are more likely to do this when the words are very typical of their categories, as with *cat* and *dog* for animals, than when the words are less typical, as with *sheep* and *fox* for animals (e.g. Bjorklund, 1988; Hasselhorn, 1992; Rabinowitz, 1984). Such results suggest that an organizational strategy is easier to access and carry out when knowledge about the category is strong than when it is weak. Knowledge about the components of the task also appears to be important in the learning of printed words, as suggested by the findings reviewed above and those of Abreu and Cardoso-Martins (1998). To examine these influences more closely, we compared three groups of children in the present study—prereaders with low letter–name knowledge (Group 1), prereaders with high letter–name knowledge (Group 2), and readers (Group 3).

Children's performance in the word-learning task may be influenced by the cognitive demands of the task as well as by the children's task-related knowledge. The role of task difficulty has been investigated in studies of memory development, where children have been found to use more sophisticated strategies with less demanding tasks than with more demanding tasks. For example, Hasselhorn (1992) examined second and fourth graders' performance in two memory tasks. In both tasks, children saw pictures of items belonging to different categories. In the sort–recall task, the child was invited to sort the pictures in the sequence that he or she deemed best for learning. In the free recall task, the experimenter presented the pictures in a fixed order and any organization had to be done mentally. Children benefited more from the categorical organization of the items in the less demanding sort–recall task than in the more demanding free recall task. These results suggest that children use more advanced strategies in an easier task than a harder task. Further support for this view comes from Rohwer and Litrownik (1983), who examined the ability of 11- and 17-year-olds to use an elaborative strategy in learning groups of words. With the pair *cat–moon*, for instance, one can imagine a cat jumping over the moon. Participants were taught to use such an elaborative strategy with pairs of words (easier task) and quadruplets of words (harder task). Participants at both age levels could learn the strategy in both the easier and the harder tasks. Both groups continued to use the strategy several days later on the easier task, when they were no longer instructed to do so. However, only the older participants continued to use the strategy on the harder task. Such outcomes have been interpreted to suggest that difficult tasks require more cognitive resources, leaving fewer resources available for participants to select and carry out a sophisticated memory strategy (Guttentag, 1997).

Although several studies have examined the effects of task difficulty on children's use of memory strategies, few studies have examined this issue with regard to reading. To do so, we varied the number of novel words that children were asked to learn in a session—either four or five. If a less demanding task frees cognitive resources for strategy selection and execution, as suggested by the memory findings, then children should be more likely to use a letter–name strategy when learning a smaller number of items than when learning a larger number of items. We tested this hypothesis by assigning approximately half of the children in each of Groups 1–3 to a condition in which four sets of print–speech pairs were taught in a single session. The remaining children had a set size of five. Set size was made a between subjects variable so that the number of sessions per child would not be unduly large. Condition—name versus sound—was a within subject variable.

1. Method

1.1. Participants

A total of 115 preschoolers contributed data. They ranged in age from 3 years, 2 months to 5 years, 9 months, with a mean age of 4 years, 8 months. All were native speakers of English. The children attended preschools and daycare centers that served primarily middle-class populations and that, like most such institutions in the U.S., did not offer formal reading instruction. The children in Group 1, prereaders with low letter–name knowledge, could produce the names of 13 or fewer letters and could read none of the tested words. Prereaders with high letter–name knowledge (Group 2) could name more than 13 letters but could not read any of the words. Readers (Group 3) correctly pronounced at least one word and knew more than 13 letter names. As Table 1 shows, there were approximately equal numbers of children in each combination of group and set size. Another 10 children began the word-learning portion of the study but did not complete it because of vacations or illnesses. One additional child was dropped due to experimenter error. Another child was dropped because she read one word but did not know more than 13 letter names, and thus did not

Table 1
Characteristics and mean performances of groups

	Group 1	Group 2	Group 3
Set size 4			
Number of children	18	20	20
Age in months	55.61 (4.73)	56.30 (3.73)	58.90 (5.85)
Number of words read (of 22)	0.00 (0.00)	0.00 (0.00)	4.15 (5.03)
Number correct on letter–name production task (of 26)	4.78 (3.84)	22.05 (3.61)	25.45 (1.05)
Proportion correct on letter–name recognition task	0.80 (0.20)	0.99 (0.03)	0.99 (0.03)
Set size 5			
Number of children	19	20	18
Age in months	52.11 (7.80)	56.80 (5.79)	57.89 (4.36)
Number of words read (of 22)	0.00 (0.00)	0.00 (0.00)	7.06 (5.92)
Number correct on letter–name production task (of 26)	5.21 (5.08)	21.30 (4.22)	25.50 (0.86)
Proportion correct on letter–name recognition task	0.68 (0.22)	0.99 (0.04)	1.00 (0.00)

Standard deviations in parentheses.

fit into any of the groups. Finally, two children who participated in the set size 5 condition were outliers in reading ability and letter–name recognition. Their inclusion caused the two set size conditions to show some significant differences on these variables, and so these children were not included in the analyses.[1]

1.2. *Stimuli and procedures*

Children met with the experimenter three times. The first session included the reading task, the letter–name production task, and the letter–name recognition task. The second session was dedicated to the word-learning task and initial-letter memory task for one of the conditions, name or visual. The remaining condition was administered in the third session. The order of the conditions and the assignment of stimulus sets to conditions were balanced across children in each group and set size condition.

1.2.1. *Reading task*

Eleven cards were used, each containing two printed words and a colored picture. The words were those that Ehri and Wilce (1985) had found to be easiest for beginning readers and were the same ones used by Bowman and Treiman (2002), Treiman and Rodriguez (1999), and Treiman et al. (2001). The pictures were included to insure that children who could not read any words could identify some items. The cards were presented one at a time in a random order, and the child was asked to identify any items that he or she knew.

1.2.2. *Letter–name production task*

This task used 26 cards, each with an upper-case letter printed on it in black. The cards were presented in a random order, and the child was asked to say the name of each letter.

1.2.3. *Letter–name recognition task*

The child was shown a card containing two black letters, separated so that they did not appear to form a word. The experimenter said the name of one of the letters and asked the child to point to it. There were eight cards for set size 4 and 12 cards for set size 5. Each initial letter from the word-learning task was used at least four times, and the order of the cards was randomized for each child.

1.2.4. *Word-learning task*

The experimenter introduced the child to a puppet and explained that the child would learn to read some of the puppet's "made-up words." The experimenter showed the child a card, ran her fingers under the letters, and told the child how the puppet pronounced the word. The word was then used in a sentence. The experimenter again ran her fingers under the letters, asked the child to repeat the word, and corrected any mispronunciations. This procedure was repeated for the remaining items, the order of which was randomly chosen. After this demonstration trial, the experimenter presented the stimuli one at a time and asked the child what each word said in the puppet's language. Guessing was encouraged, incorrect

[1] This decision was made to facilitate comparison between the two set size conditions. When the data from these children were included in the analyses, the results were very similar to those reported.

responses were corrected, and correct responses were praised. This process continued for up to eight trials. The child was considered to have reached criterion if he or she responded correctly to all of the stimuli on two consecutive trials. If so, no further trials were presented and we assumed that these trials would have been correct. The items were presented in a random order on each test trial with the stipulation that the last word of one trial was not the first word of the next trial.

In the set size 4 condition, there were two sets of four stimuli each (Set A and Set B) in the name condition and two sets of stimuli in the visual condition. The set size 5 condition contained two five-item sets. All of the printed stimuli were composed of two consonant letters, which were printed in upper case. The stimuli and their pronunciations appear in Appendix A. The corresponding items in the name and visual conditions had the same pronunciations. The items in each pair differed in their initial letters, which are the most salient letters for children of this age (e.g. Bowman & Treiman, 2002). The final letters in each pair were the same and were alphabetic representations of the final sounds of the items' pronunciations. In the name condition, the letters were uniform in height (35 mm) and color (black). The entire name of the first letter of the printed item was heard in the word's pronunciation. For example, TZ was pronounced *tease*. In the visual condition, the initial letters and pronunciations were scrambled so that first letter of the printed item did not correspond to the expected phoneme in the item's pronunciation. However, the letters of these items varied in color, height (16–55 mm for the second letter, with the initial letter always 35 mm high), and position (with the baseline of the second letter ranging from 23 mm above the baseline of the first letter to 20 mm below it). For example, KZ in the set size 5 condition, which represented *tease*, was printed with a pink K 35 mm high and a green Z 27 mm high that was placed immediately to the right of and below the K. No two stimuli within a set in the visual condition had the same color pattern. Letter position and color were matched across Sets A and B. Within each set, each printed stimulus had unique initial and final letters. No letter appeared in both the initial and final position.

1.2.5. Initial-letter memory task

To assess children's ability to remember the initial letters of the words they were taught, we prepared cards that were similar to those for the letter–name recognition task except that the letters were red. By using a color that did not appear in any of the stimuli for the word-learning task we could tap abstract memory for letter identity. Four cards were prepared for set size 4, with the letters on each card corresponding to the two beginning letters that were taught for each pronunciation. For *tease*, for example, the choices were T (the first letter in the name condition spelling and phonetically appropriate) and K (the first letter in the visual condition spelling and not phonetically appropriate). Five cards were used for set size 5. The memory cards were presented after the child had reached criterion in the word-learning task or had completed eight trials. The child was asked to choose which of the two letters on each card was the first letter in the puppet's word.

A word-learning task that involves incorrect spellings of words poses potential ethical problems. Several procedures were followed to minimize such problems. We presented the words as in a puppet's language, not as real English spellings, and we reminded the children of this periodically. The children were shown the correct spellings of all the words at the end of the experiment.

2. Results

2.1. Preliminary analyses

Table 1 shows the means for the three groups in each set size condition for age, number of words read, number correct on the letter–name production task, and proportion correct on the letter–name recognition task. Recall that Group 1 consisted of nonreaders who were not very knowledgeable about letter names, Group 2 of prereaders who were more knowledgeable about letter names, and Group 3 of children who could read at least one word. We performed separate analyses of variance (ANOVAs) using the between-subjects factors of group and set size for each variable. The main purpose of these analyses was to check that the children in the two set size conditions were similar in age, reading ability, and letter–name knowledge. Confirming that they were equivalent, no significant effects involving set size were found in any of the analyses. For age, the only significant effect was that of group (F (2, 109) = 6.33, $p = 0.003$). Post-hoc tests using Tukey's HSD showed that Group 1 was significantly younger than Group 3 ($p = 0.001$). For reading ability, the effect of group was again significant (F (2, 109) = 40.39, $p < 0.001$). As expected, Group 3 read reliably more words than Groups 1 or 2 ($p < 0.001$ for both comparisons). For the letter–name production test, the only significant effect was the main effect of group (F (2, 109) = 362.94, $p < 0.001$). Group 1 named significantly fewer letters than Group 2 ($p < 0.001$), and Group 2 in turn named significantly fewer letters than Group 3 ($p < 0.001$). The letter–name recognition test also showed a main effect of group (F (2, 109) = 52.29, $p < 0.001$). Group 1 recognized significantly fewer letters than Groups 2 and 3 ($p < 0.001$ for both). However, children in all three groups performed reliably above the chance level of 0.50 in the letter–name recognition task ($p < 0.001$), showing that they had some knowledge about the names of the initial letters of the stimuli in the word-learning task.

2.2. Word-learning task

Fig. 1 shows the proportion of correct responses across trials for the three groups of children at each set size. An ANOVA using the within-subject variables of condition (name versus visual) and trial (1–8) and the between-subjects variables of reading group (Group 1 versus Group 2 versus Group 3) and set size (4 versus 5) was performed. Because of correlations across trials, multivariate tests were used. Main effects of group (F (2, 109) = 28.18, $p < 0.001$), set size (F (1, 109) = 13.48, $p < 0.001$), and trial (F (7, 103) = 35.34, $p < 0.001$) were found. These main effects were qualified by several interactions. Trial interacted with group (F (14, 208) = 3.23, $p < 0.001$). This interaction reflects the fact, visible in figure, that Groups 2 and 3 improved more across trials than Group 1. Two other interactions were significant, that between condition and group (F (2, 109) = 6.33, $p = 0.003$) and that between condition and set size (F (1, 109) = 3.91, $p = 0.050$).

Given the significant interactions involving set size and group, we examined the results for each group at each set size using the within-subjects factors of condition and trial. With four-item sets, Group 1 (prereaders with low letter–name knowledge) performed significantly better in the visual condition than the name condition (F (1, 17) = 7.84, $p = 0.012$). Neither Group 2 (prereaders with high letter–name knowledge) nor Group 3

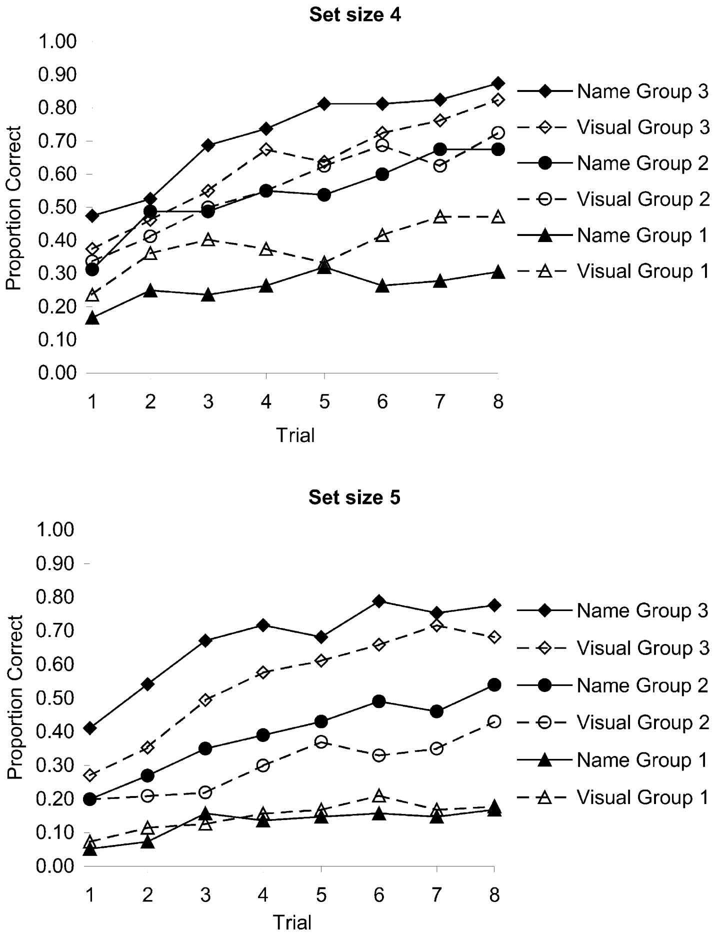

Fig. 1. Proportion correct as a function of trial, condition and group for set size 4 and set size 5.

(readers) showed a main effect of condition. The tendency for Group 3 to perform better in the name condition than the visual condition was not statistically reliable. These patterns are summarized in Table 2, which shows the mean proportion of correct responses on the word-learning task in the two conditions for each set size, pooling across trials. The analyses for set size 4 also showed a significant main effect of trial for Group 2 (F (7, 13) = 9.64, $p < 0.001$) and Group 3 (F (7, 13) = 15.47, $p < 0.001$), but not for Group 1.

The results presented above were supported by an examination of performance on individual items in the set size 4 condition. Group 1 performed better in the visual condition than the name condition for seven of the eight items. The remaining word showed identical results in the two conditions. For Group 2 and Group 3, half the items yielded better performance in the name condition and the other half yielded better performance in the visual condition.

Turning to set size 5, Group 1 performed at a similar and low level in the name and the visual conditions. For this group, half the items yielded better performance in the name

Table 2
Mean proportion of correct responses on word-learning task pooled across trials

	Group 1	Group 2	Group 3
Set size 4			
Name condition	0.26 (0.24)	0.54 (0.30)	0.72 (0.24)
Visual condition	0.38 (0.35)	0.55 (0.21)	0.63 (0.26)
Set size 5			
Name condition	0.13 (0.15)	0.39 (0.28)	0.65 (0.29)
Visual condition	0.15 (0.15)	0.30 (0.23)	0.52 (0.29)

Standard deviations in parentheses.

condition and the other half yielded better performance in the visual condition. Group 2 did not show a significant main effect of condition. However, this group showed a trend toward better performance in the name condition, with superior performance in the name condition for seven of the 10 items. Group 3 performed reliably better in the name condition than the visual condition (F (1, 17) = 14.46, $p = 0.001$). Performance was better in the name condition than the visual condition for nine of the 10 words, with equal performance in the two conditions on the final word. This is a different pattern of results than that shown by Group 3 in the set size 4 condition, where no significant difference between the conditions was observed. Group 1 did not show a significant main effect of trial. A main effect of trial was found for Group 2 (F (7, 13) = 4.55, $p = 0.009$) and Group 3 (F (7, 11) = 23.27, $p < 0.001$).

To summarize, children who were relatively knowledgeable about letters and about reading were more likely than less knowledgeable children to perform better in the name condition than the visual condition. This pattern accounts for the significant interaction between condition and group in the overall analysis. It points to an effect of task-related knowledge on children's learning. The demands of the task also influenced children's performance. Children were more likely to perform better in the name condition than the visual condition when learning sets of five items than when learning sets of four items, as reflected by the significant interaction between condition and set size. That is, the children showed a more advanced pattern of performance with a harder task than an easier task.

We also examined the proportion of children who reached the criterion of two consecutive correct trials in the word-learning task for each combination of group and set size. The results are shown in Table 3. As a chi-square test was not appropriate, an ANOVA

Table 3
Proportion of children who reached criterion of two consecutive correct trials in word-learning task

	Group 1	Group 2	Group 3
Set size 4			
Name condition	0.06	0.30	0.60
Visual condition	0.22	0.35	0.45
Set size 5			
Name condition	0.00	0.15	0.44
Visual condition	0.00	0.00	0.44

Table 4
Mean proportion of correct responses on initial-letter memory task

	Group 1	Group 2	Group 3
Set size 4			
Name condition	0.60 (0.23)	0.81 (0.21)***	0.88 (0.19)***
Visual condition	0.51 (0.23)	0.50 (0.30)	0.59 (0.35)
Set size 5			
Name condition	0.56 (0.23)	0.78 (0.26)***	0.87 (0.18)***
Visual condition	0.44 (0.22)	0.31 (0.29)**	0.32 (0.31)*

Standard deviations in parentheses.
* Significantly different from chance level of 0.50, $p < 0.05$, two-tailed.
** Significantly different from chance level of 0.50, $p < 0.01$, two-tailed.
*** Significantly different from chance level of 0.50, $p < 0.001$, two-tailed.

was run with the expectation that power would be decreased. Main effects of set size (F (1, 109) = 5.95, $p = 0.016$) and group (F (2, 109) = 14.38, $p < 0.001$) were found. Children were more likely to reach the criterion with four-item sets than five-item sets. Also, readers (Group 3) were more likely to achieve criterion than prereaders (Groups 1 and 2). No other effects were significant.

2.3. Initial-letter memory task

Table 4 shows the proportion of correct responses in the memory task, where children were asked to choose which of two letters was the first letter in each of the puppet's words. An ANOVA using the factors of condition, reading group, and set size revealed a main effect of group (F (2, 109) = 6.10, $p = 0.003$), with Group 1 generally performing more poorly than Groups 2 and 3. A main effect of set size also emerged (F (1, 109) = 10.48, $p = 0.002$). Overall, memory performance was better with four-item sets than with five-item sets. There was also a main effect of condition (F (1, 109) = 70.82, $p < 0.001$). As in the analysis of the learning trials, the main effects were qualified by interactions between condition and group (F (2, 109) = 7.85, $p = 0.001$) and condition and set size (F (1, 109) = 4.30, $p = 0.04$). Given the interactions, we examined the results for each group separately at each set size.

With four-item sets, Group 1 (prereaders with low letter–name knowledge) performed at similar levels in the name and visual conditions. Their performance did not differ significantly from the chance level of 0.50 in either condition. The same results were found with five-item sets for Group 1 children. Group 2 (prereaders with high letter–name knowledge) performed significantly better in the name condition than the visual condition for both set sizes (t (19) = 3.87 and 4.92, for set sizes four and five, respectively; $p < 0.001$ for both). Likewise, Group 3 (readers) performed significantly better in the name condition than the visual condition for both set sizes (t (19) = 3.44, $p = 0.003$; t (17) = 6.27, $p < 0.001$, for set sizes four and five, respectively). Importantly, as reflected in the significant interaction between condition and set size, the superiority for the name condition over the visual condition was larger with five-item sets than four-item sets. This interaction further supports the idea that children tend to use a more advanced strategy with the larger set than with the smaller set. With sets of four, Groups 2 and 3 performed significantly above chance

Table 5
Correlations of proportion correct responses in word-learning task and initial-letter memory task with letter–name knowledge and reading ability

	Letter–name production	Letter–name recognition	Words read
Word-learning task, name condition	0.65[a,***]	0.40***	0.49***
Word-learning task, visual condition	0.47***	0.34***	0.39***
Initial-letter memory task, name condition	0.49[a,***]	0.37[a,***]	0.31[a,***]
Initial-letter memory task, visual condition	−0.09	−0.13	−0.02

[a] Correlation with name condition significantly higher than correlation with visual condition, $P < 0.05$, one-tailed.

*** $p < 0.001$, two-tailed.

on the memory task in the name condition but were indistinguishable from chance in the visual condition. With five-item sets, Groups 2 and 3 performed significantly above chance in the name condition and significantly *below* chance in the visual condition. For example, these children tended to pick T as the first letter of the puppet's word *tease* even when they had just been taught a spelling with an initial K. The children's knowledge of letter names apparently interfered with their ability to remember the arbitrary initial letters that were taught in the visual condition.

2.4. Correlational analyses

Table 5 shows the correlations between children's performance in the word-learning and memory tasks and their knowledge of letter names and reading ability. Children's performance in the name condition was more closely related to their knowledge about letters and reading than was their performance in the visual condition, although the differences between the correlation coefficients were not always statistically reliable.

3. Discussion

We designed this study to investigate how young children connect print and speech before they have been formally taught to read. To shed light on children's untutored strategies, we compared their ability to learn two types of print–speech pairs. In the name condition, the entire name of the first letter of each printed item was heard in the item's pronunciation. This condition mimics the print–speech relationships that are found in real English words such as *jail* and *eat*. It gives children the opportunity to use their knowledge of letter names to form partial links between printed items and their pronunciations. In the visual condition, the first letters of the printed items bore no systematic relationship to the items' pronunciations. However, each item in the set was distinctive in color pattern, letter height, and letter position, making these stimuli somewhat similar to many commercial logos. This condition gives children the opportunity to select visually salient characteristics of the printed items and link these to the items' pronunciations. Relative performance in the two conditions should thus reflect the balance between systematic, letter-based strategies and non-systematic, visual strategies. The goal of our study was to determine how this balance varied with the knowledge of the children and the demands of the task.

Consider, first, the results for prereaders who were not very knowledgeable about the names of letters (Group 1). These children appeared to have a single method for learning the associations between print and speech, one that was based on rote memorization. This method permitted some degree of success when four pairs were presented in a single session, especially when the printed stimuli were distinctive in the color and arrangement of their letters. When five items were presented in a single session, the children in Group 1 performed poorly whether the items in the set were visually distinctive or not. The single strategy that they had available, which was based on rote memorization, apparently broke down with an increase in the number of items to be learned. A further limitation of the visual memorization approach is that it did not support good memory for the printed items. When the colors of the letters changed, the children could not remember the first letters of the items after a brief delay.

The children in Groups 2 and 3, unlike those in Group 1, seemed to possess two strategies for learning the print–speech pairs. The first was a non-analytic method based on rote memorization, the same method that was available to the Group 1 children. The second method, which was apparently made possible by these children's greater knowledge about letter names, was more analytic and letter-based. With a set size of five, the children in Groups 2 and 3 showed evidence of use of the analytic method in their learning and memory for the print–speech pairs. With a set size of four, there were few signs of an analytic method. This outcome—a more advanced pattern of performance with the harder task (five-item sets) than the easier task (four-item sets)—differs from the pattern that has been reported in the memory literature. In the memory studies that we reviewed, children used more advanced strategies with easier tasks than with harder tasks (e.g. Hasselhorn, 1992; Rohwer & Litrownik, 1983). This difference is thought to arise because less demanding tasks free cognitive resources for strategy selection and execution (Guttentag, 1997).

Why did the children in Groups 2 and 3 show a more advanced pattern of performance in the harder reading task than the easier reading task? One view, the strategy choice view, follows from the work of Siegler and colleagues (e.g. Rittle-Johnson & Siegler, 1999; Siegler, 1996). According to this view, the children selected different strategies in the two set size conditions. These choices reflected their tacit weighting of the costs and benefits of the different learning methods (Guttentag & Lange, 1994). Children chose the rote memorization strategy when learning a small number of print–speech pairs because this approach was fairly likely to succeed in this case. When only a few items had to be learned at once, the benefits of an analytic approach did not outweigh the increased effort that it required. When children had to learn a larger number of pairs in a single session, they were more likely to use an analytic strategy because the effort that was needed to encode the associations between the first letters in the printed words and the first sounds in the spoken words was recouped by the better performance that this method permitted. According to the strategy choice view, children who have the knowledge that is required to relate print and speech on the basis of letter names are more likely to use this knowledge in a demanding situation than in a less demanding situation. The effect of task difficulty is the opposite of that observed in the memory studies because the more sophisticated strategy, in the reading case, is tailored to the requirements of the harder task. Systematic relationships between letters and their names make it easier to learn a large number of words by allowing parts of the words' pronunciations to be derived rather than memorized.

An alternative view, which we may call the strategy outcome view, focuses on the relative efficacy of the strategies rather than on strategy choice. According to this view, the children in Groups 2 and 3 used both the analytic and the non-analytic methods at both set sizes. With four-item sets, the rote memorization method worked almost as well as the analytic method, and the children experienced almost as much success in the visual condition as in the name condition. Rote memorization was not as successful with five-item sets, and so performance in the visual condition was significantly worse than performance in the name condition. What changed as a function of task difficulty, according to the strategy outcome view, was the relative success of the two strategies, not children's choices between the strategies.

Regardless of whether we explain the observed differences between the two set sizes in terms of strategy choices or strategy outcomes, our results suggest that increasing the difficulty of a task is not necessarily harmful to children. A more demanding task can sometimes push children forward, encouraging them to use more sophisticated approaches than they otherwise would. When teaching children to read, increasing the number of words that are presented in a single session can encourage the children to take advantage of any alphabetic knowledge that they possess. With U.S. preschoolers, who often have some knowledge about the names of letters, this can help them benefit from certain systematic relationships between print and speech. If children are not given a push, they may continue to rely on a more primitive memorization strategy.

Our findings support the view that young children who are familiar with the names of letter can use this knowledge to help bridge the gap between speech and print (e.g. Treiman & Kessler, 2003). This holds true for English-speaking children, as well as for children learning to read in such languages as Portuguese (Abreu & Cardoso-Martins, 1998) and Hebrew (Levin, Patel, Margalit, & Barad, 2002). Words that permit children to make partial connections between print and speech on the basis of letter names, such as *eat* and *jail*, may have an important role to play in early reading instruction by helping children understand that the spellings of words are systematically related to their sounds.

In phonics-based approaches to reading instruction, words such as *bat*, *pat*, *bet*, and *pet* are taught close to one another in time. In contrast, whole-word instruction often has children learn groups of words that are conceptually similar but visually and phonologically different, such as *pet*, *hamster*, and *fish*. A child who knows relatively little about letters and reading, like the children in Group 1 of our study, may learn a few visually distinctive words through a whole-word method. However, such a child's performance will deteriorate when the number of words to be learned increases (as in the set size 5 condition of the present study) or when the words become similar to one another (as in the name condition of the present study or in phonics instruction). Such children will also have difficulty remembering the words they have learned, as our results show. To take advantage of the systematic relations between spellings and sounds that exist in an alphabetic writing system, and to benefit from phonics instruction, children must be provided with knowledge about letters and phonological skills. They must also be encouraged to put these skills to use in learning to read words. One way to do this, our results suggest, is to place children in situations in which rote memorization will not work well. Increasing the number of words to be learned in a single session is one way to do this.

Acknowledgments

This research was supported in part by NSF Grants SBR-9807736 and BCS-0130763. Some of the data were presented at the April 2001 meeting of the Society for Research in Child Development. Hilary Ratner, Lee Wurm, and Margo Bowman made valuable contributions to the project, and Brett Kessler, Iris Levin, and Robert Siegler provided helpful comments on a draft of the manuscript.

Appendix A

Pairs of visual stimuli and pronunciations for word-learning task (colors for first and second letters of visual condition stimuli in parentheses)

Set	Pronunciation	Set size 4		Set size 5	
		Name condition	Visual condition	Name condition	Visual condition
A	tease	TZ	K_Z (green, yellow)	TZ	K_Z (pink, green)
	bean	BN	D^N (blue, orange)	BN	T^N (orange, blue)
	deep	DP	tP (yellow, blue)	DP	cP (purple, orange)
	cave	KV	Bv (orange, green)	KV	Bv (blue, pink)
	seem			CM	D^M (green, purple)
B	team	TM	K_M (green, yellow)	TM	K_M (pink, green)
	beef	BF	D^F (blue, orange)	BF	T^F (orange, blue)
	deal	DL	tL (yellow, blue)	DL	cL (purple, orange)
	cape	KP	Bp (orange, green)	KP	Bp (blue, pink)
	seen			CN	D^N (green, purple)

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