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Learning Letter Names and Sounds: Effects of Instruction, Letter Type, and Phonological Processing Skill

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Abstract

Preschool-aged children (*n* = 58) were randomly assigned to receive instruction in letter names and sounds, letter sounds only, or numbers (control). Multilevel modeling was used to examine letter name and sound learning as a function of instructional condition and characteristics of both letters and children. Specifically, learning was examined in light of letter name structure, whether letter names included cues to their respective sounds, and children's phonological processing skills. Consistent with past research, children receiving letter name and sound instruction were most likely to learn the sounds of letters whose names included cues to their sounds, regardless of phonological processing skills. Only children with higher phonological skills showed a similar effect in the control condition. Practical implications are discussed.

Keywords

emergent literacy; alphabet; letter names; letter sounds; phonological processing

Learning Letter Names and Sounds: Effects of Instruction, Letter Type, and Phonological Processing Skill

Alphabet knowledge is essential for learning to read and spell in English (Adams, 1990; Ehri, 1987, 1998). Along with oral language and phonological awareness, it represents one of the most important emergent literacy skills acquired by young children (Whitehurst & Lonigan, 1998). Children's alphabet knowledge has long been deemed one of the best predictors of later word reading ability (e.g., Adams, 1990; Hammill, 2004; Scarborough, 1998; Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004). Likewise, failure to acquire such knowledge is an important indicator of risk for later reading difficulties (e.g., Gallagher, Frith, & Snowling, 2000; O'Connor & Jenkins, 1999; Torppa, Poikkeus, Laakso, Eklund, & Lyytinen, 2006).

The significance of alphabet knowledge for acquiring literacy skills is reflected in many recent initiatives. For example, many state curriculum frameworks include letter name and sound learning for young children (Florida Department of Education, n. d.; Massachusetts

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Department of Education, 2001; Ohio Department of Education, 2007). Both the Early Reading First and Reading First programs set explicit goals seeking to increase participants' letter knowledge and understanding of letter-sound correspondences (U. S. Department of Education, 2002; 2003), as does the Head Start program (U.S. Department of Health and Human Services, Administration for Children and Families, 2003). Early childhood curricula used in preschool and kindergarten classrooms commonly include an alphabetic component (Justice, Pence, Bowles, & Wiggins, 2006). These curricula vary markedly in how alphabet knowledge is taught, a reflection perhaps of our current lack of knowledge about letter name and sound development and best practices for fostering their acquisition (Piasta & Wagner, in press). Despite widespread agreement as to the importance of letter name and sound knowledge, we know much less about children's alphabet knowledge development than we do about the development of other emergent literacy skills.

In the present study, we modeled children's gains in alphabet knowledge as a result of targeted letter name and/or sound instruction to examine the role of letter names in promoting letter sound acquisition. In doing so, we sought not only to answer basic research questions concerning children's alphabet development, but also to provide insight into how such knowledge might translate into practice in early childhood classrooms.

Development of Alphabet Knowledge: Effects of Letter Properties and Child Characteristics

Letter properties—A number of letter properties appear to affect the ease with which their names and sounds are learned. These include whether the letter is a consonant or vowel, the letter's position within the alphabet, its manner of articulation, whether the letter is associated with more than a single sound (e.g., B and /b/ versus C and /k/, /s/), the age at which the sound is typically produced, the confusability of the letter's shape or pronunciation with other letters, and frequency in print materials (Evans, Bell, Shaw, Moretti, & Page, 2006; Justice et al., 2006; McBride-Chang, 1999; Treiman & Kessler, 2003; Treiman, Kessler, & Bourassa, 2001; Treiman, Kessler, & Pollo, 2006; Treiman, Levin, & Kessler, 2007; Treiman, Tincoff, Rodriguez, Mouzaki, & Francis, 1998).

The present study focused on one particular letter property: letter name structure. Letter name structure refers to how letter sounds are represented in their names, and has been found to influence knowledge of letter sounds in young children (Evans et al., 2006; Justice et al., 2006; Levin, Shatil-Carmon, & Asif-Rave, 2006; McBride-Chang, 1999; Read, 1971; Treiman, Berch, & Weatherston, 1993; Treiman, Pennington, Shriberg, & Boada, 2008; Treiman, Tincoff, & Richmond-Welty, 1996, 1997; Treiman et al., 1998; Treiman, Weatherston, & Berch, 1994). Many letter names contain their corresponding sounds, taking one of two forms: the consonant-vowel (CV) pattern of /consonant sound/ + /i/ as in the letter B, or the vowel-consonant (VC) pattern of /ε/ + /consonant sound/ as in the letter F. Preschoolers are well aware of these regularities, particularly the consonant-vowel form (Treiman et al., 1997). These results are consistent with the idea that children use their segmentation abilities and the initial sounds of letter names as cues for the letters' sounds. Treiman and colleagues (Treiman et al., 1997; 1998) reported that children were more likely to know the sounds of letters in which the first sound of the letter name correctly corresponds to its sound (i.e., CV letters) than with names that began with a vowel (i.e., VC letters) or letters with names and sounds that are not associated (i.e., NA letters like W) (see also McBride-Chang, 1999; Justice et al., 2006).

The letter name-to-sound facilitation effect suggested by this correlational research has been investigated in three training studies (see also de Jong, 2007). Using a completely within-subjects design, Treiman et al. (1998) demonstrated that the effect was due to ease of learning and not factors extrinsic to the child. Moreover, two recent studies conducted with Hebrew-speaking students have provided some experimental evidence supporting the letter name facilitation effect. Share (2004) showed an advantage in pseudoletter learning when associated names and sounds were taught. Levin and colleagues (Levin et al., 2006) demonstrated that children taught letter names attempt to use this knowledge in extrapolating letter sounds. The validity of these results for English-speaking children in typical U.S. preschool settings, however, remains to be tested.

Child characteristics—Other researchers have focused on influences of child characteristics on alphabet knowledge acquisition. These include the letters in children's names (Treiman & Broderick, 1998; Treiman, Cohen, Mulqueeny, Kessler, & Schechtman, 2007; Treiman & Kessler, 2004), as well as various cognitive and emergent literacy skills (e.g., oral language, memory, print awareness, rapid naming, and phonological processing; Burgess & Lonigan, 1998; de Jong & Olson, 2004; Evans et al., 2006; Lonigan, Burgess, & Anthony, 2000; Mann & Foy, 2003). Phonological processing, in particular, may play an important role in alphabet knowledge development. Phonological processing refers to children's awareness of and ability to manipulate segments (phonemes, onsets/rimes, syllables) of language, and is related to both word reading ability (e.g., Lonigan et al., 2000; Torgesen, Wagner, & Rashotte, 1994; Wagner & Torgesen, 1987; Wagner, Torgesen, & Rashotte, 1994; Wagner et al., 1997), and letter name and sound knowledge (e.g., Burgess & Lonigan, 1998; Lonigan, Burgess, Anthony, & Barker, 1998; Mann & Foy, 2003; McBride-Chang, 1999; Share, 2004; Wagner et al., 1994).

Relations between phonological processing and alphabet knowledge are relatively robust. Phonological processing is a unique predictor of letter name and letter-sound knowledge after other characteristics have been controlled (Burgess & Lonigan, 1998; Lonigan et al., 2000), and it accounts for individual differences in children's alphabet knowledge above and beyond environmental factors such as home literacy environment or alphabet instruction from parents (Torppa et al., 2006). Together with intervention work demonstrating the combined benefit of phonological plus alphabet training on letter sound outcomes (e.g., Ball & Blachman, 1991), these results are consistent with bidirectional relations between letter name and sound knowledge and phonological processing skill (Burgess & Lonigan, 1998; Foulin, 2005; McBride-Chang, 1999). Letter knowledge influences phonological skill and phonological skill influences letter learning. In fact, phonological skill may provide the mechanism by which the letter name-to-sound facilitation effect occurs (Piasta, 2006; Share, 2004). Children must use their phonological abilities to derive the letter sound from its name, isolating the corresponding sound from the full syllable of the letter name (e.g., /b/ from /bi/). Share (2004) found preliminary evidence supporting this hypothesis in the small to moderate correlations between phonemic analysis and letter sound gains in his experimental sample.

The Present Study

The present study was carried out to investigate the letter name-to-sound effect on the alphabet learning of U.S. preschool children. We implemented three training conditions: (1) combined letter name and sound instruction, (2) letter sound only instruction, and (3) number identification instruction as a treated control. Basic results concerning the overall impacts of the various training conditions are presented in Author (in press). The letter name-to-sound effect investigated in the present analyses was tested via the counterfactual produced by the combined letter name and sound versus letter sound only comparison, in which only letter name instruction was manipulated. These results were also compared to findings for the treated control, representing typical learning without experimental manipulation. Note that a condition providing only letter name instruction was not included because this did not represent a counterfactual of interest (i.e., a difference in letter sound learning between letter sound only and letter name only instructional conditions could have been due to the provision letter sound instruction in one condition but not the other, rather than provision of letter name instruction) and was not practically feasible, given resource and statistical power limitations.

Of particular interest in the present study was an examination of the letter name-to-sound facilitation effect on children's alphabet learning. Specifically, we examined whether particular types of letters were more likely to be learned and whether such learning was moderated by children's phonological abilities. The letter name-to-sound effect ought to hold only for those letters whose names provide cues to their sounds. Thus, any advantage of combined letter name and sound instruction should be limited to CV and VC letters, to the exclusion of NA letters. Furthermore, the letter name-to-sound effect mainly ought to benefit children capable of segmenting letter names into their constituent sounds. Consequently, positive relations between phonological abilities and letter sound learning were expected for CV and VC letters, and children with higher phonological abilities were expected to show a more pronounced letter name-to-sound effect for CV and VC letters as compared to children with lower phonological abilities. Acquisition of NA letters should not be dependent on phonological skill. Finally, we also examined children's acquisition of vowel letters although such analyses were largely exploratory in nature. Although some studies suggest that vowels are often more familiar than consonants (Evans et al., 2006; Treiman et al., 1998), evidence concerning the effects of instruction and letter name-to-sound facilitation did not support specific predictions for vowel learning.

Examining interactions between training, letter, and child characteristics is facilitated by recent statistical advances allowing for the study of both letter- and child-factors simultaneously. The study integrates a body of research that had previously focused exclusively on either letter or child characteristics. A multilevel analytic technique was required to examine the anticipated interactions among training condition, letter name structure, and phonological processing. The advantages of this technique are discussed further in the following section.

Advantages of Multilevel Analysis

As indicated, studies of alphabet knowledge acquisition have typically involved the investigation of either letter properties or child characteristics, but not both simultaneously. One problem for simultaneously investigating such factors has been limitations in statistical methods that preclude examination of effects from two units of analysis (i.e., letters and children) simultaneously. Studies with letters as units of analysis necessarily ignored the variability that exists among children (cf. Justice et al., 2006), whereas studies with children as the units of analysis ignored the variability that exists among letters. This problem is akin to the "language-as-a-fixed-effect fallacy" debated in the cognitive literature (Clark, 1973; Coleman, 1964), with the same model misspecification problems that can result in biased estimates of effects and errors in significance testing (Clark, 1973; Lorch & Myers, 1990; Richter, 2006). Multilevel modeling provides a solution to this problem (Raudenbush & Bryk, 2002). Generalized multilevel models allow for the simultaneous examination of the effects of both letter properties and child characteristics on alphabet knowledge (see Richter, 2006; for further discussion regarding the use of multilevel models when both stimuli and participant effects are of interest). Combining the effects of letter properties and child characteristics in the same study of letter name and letter sound knowledge confers important theoretical, statistical, and practical advantages.

First, the simultaneous examination of effects of both letters and children on alphabet knowledge allows for the generation and testing of new hypotheses. In the present case, these new hypotheses concerned possible interactions among instructional condition, letter name structure, and phonological processing skill. Incorporation of interaction terms also confers statistical benefits in preventing model misspecification. As a rule, interactions between factors modify the interpretation of either factor's main effect alone (Maxwell & Delaney, 2004). Thus, if interactions between letter properties and child characteristics are found, previous interpretations of either the letter property or child characteristic effects need to be amended.

Multilevel models also correctly partition the variance in alphabet knowledge into its two sources: variability due to differences among letters and variability due to differences among children (Evans et al., 2006). Estimates of effects are unbiased, and significance tests are corrected. Significant results may be interpreted as reliable across both units of analysis. The robustness of effects across letters is particularly important to note. An effect that is reliable across letters is interpreted as holding, on average, for *all* letters, regardless of other properties specific to individual letters (e.g., letter frequency or exposure, position in alphabet;). The results are robust despite allowing such factors to vary.

The multilevel model used in the present study also does not assume a normal distribution, addressing arguments that alphabet knowledge is a "constrained skill" (Paris, 2005; Paris, Carpenter, Paris, & Hamilton, 2005) for which parametric analyses may not be appropriate. Instead, letters are scored dichotomously, as correct or incorrect, and this dichotomous data serves as the outcome of interest in the (generalized) multilevel model. In this way, the model is essentially a multilevel logistic model, giving odds ratios or probabilities of correctly responding to letters with particular characteristics.

Lastly, integrated analysis of letter properties and child characteristics in multilevel models may aid in clarifying those factors genuinely related to children's acquisition of alphabet knowledge, and thus may have practical value for instruction. For example, learning might become more efficient if the time spent learning different letters reflected their differential difficulty. The present study begins to tackle such questions when considering the effectiveness of two approaches to alphabet instruction on the learning of CV, VC, and NA letters.

Method

Participants

Four private childcare centers located in a mid-sized Southeastern city participated in the study. Center staff distributed consent forms to parents of English-speaking, 3- and 4-year old children demonstrating little familiarity with alphabet letters.

Of children with parental consent (N = 113), 63 met eligibility criteria for participation in the study. These children produced fewer than eight letter names on an uppercase letter name production task.[1] The sample was unrestricted with regard to gender, ethnicity, or socioeconomic status. Five eligible children moved or withdrew participation prior to study completion. These children did not significantly differ from the final sample on demographic, screening, or pretest measures (ps > .126) with the exception of letter sound production. Non-completing children were unfamiliar with any letter sounds at pretest ($M = 0$) whereas children who completed the study knew, on average, 1 letter sound, Welch test $F(1, 57) = 14.80$, $p < .001$.

Table 1 presents sample characteristics for the 58 children completing the intervention. The majority of children in the sample (72%) were Caucasian, with 14% African-American and 14% of other ethnicities (Indian, Hispanic, or Asian). Forty-eight percent of the sample was female. Fifty percent of the children had parents who had graduated from college, and 9% of parents had additional post-graduate training. Parents of three children did not provide educational information.

[1]The cutoff of eight letter names was determined through examination of a large database containing information on over 1,000 3- and 4-year old children living in the same mid-sized Southeastern city. Knowledge of eight or fewer letter names represented below-average letter knowledge for children of this age (C. Lonigan, personal communication, June 13, 2007).

Children were randomly assigned to condition using a block-randomization technique (Shadish, Cook, & Campbell, 2002) to better ensure the initial equivalency of groups. Within each classroom, children were blocked as to their initial alphabet knowledge, with one member of each block assigned to each of the three instructional conditions. With the stipulation that the overall number of children in conditions be as equivalent as possible, simple random assignment was employed to assign the final pair or individual child to a condition when the number of participating children in a classroom was not a multiple of three. Children were also randomly assigned to the small groups through which instruction was delivered, with each small group including children from multiple classrooms. In this manner, neither condition nor small groups were confounded with initial alphabet knowledge levels, Centers, teachers, or classes.

Instruction

In each condition, an 8-week curriculum (34 10- to 15-min lessons) was delivered to small groups of three to five children as a pull-out program. Instruction was implemented by the researcher and two research assistants. Beyond knowing that the instructional conditions were being compared, the two research assistants were blind to the study's specific aims. Each implementer provided instruction in all three conditions to avoid confounding intervention condition with implementer. Implementers were trained to properly deliver the lessons during two training sessions prior to the start of the study. During these sessions, lesson plans and instructional materials were distributed, and implementation was modeled by the researcher. Implementation was monitored throughout the course of the study. Audio recordings of 30% of all lessons were reviewed by the researcher, with implementation issues discussed as they arose.

Fifteen percent of all lessons were randomly selected to formally assess fidelity. These audio recordings were coded for the presence/absence of key lesson components as detailed in the lesson scripts, as well as the misuse of letter names in the letter sound only condition. Coders were blind to the study's hypotheses and achieved 100% agreement with master-coded training lessons. Double-coding of 20% of the fidelity recordings indicated continued high interrater reliability ($\kappa = .93$).

Combined letter name and sound and letter sound only conditions—All alphabet lessons were similar in format; conditions differed solely in whether letter names were taught in addition to letter sounds. In the combined letter name and sound condition, the letter was consistently referred to by its name and linked to its most common corresponding sound (e.g., the letter C that makes the sound /k/) in all lesson activities, further described below. In the letter sound only condition, the letter was designated only through reference with its corresponding sound (e.g., the letter that makes the /k/ sound) by both implementer and children. Twenty-six individual letter lessons and eight review lessons were developed, for a total of 34 alphabet lessons. Lessons were consistent in materials and instructional activities across all letters and in both alphabet instruction conditions. The most common sound associated with individual letters (e.g., /k/ for C, /g/ for G) and short vowel sounds (e.g., /æ/ for A, /α/ for O) were taught. Lessons followed a fixed random sequence (T, J, S, N, M, G, A, V, H, W, P, Z, O, C, Q, E, B, Y, R, K, U, I, F, X, D, L) to avoid bias due to typical alphabet order (McBride-Chang, 1999).

The individual letter lessons focused on a single uppercase letter and sound, and three to four such lessons were provided per week. Although lessons were scripted, instruction was delivered in an interactive manner appropriate for the preschool setting. Children practiced saying the letter name and/or sound, recognized the letter from an array of magnetic letters, and listened for words starting with the letter sound, as aided by picture cards (see Appendix for sample lessons). To enable unbiased comparisons across letters with varying letter name structures, the same lesson format was used for teaching every individual letter.

Review lessons occurred weekly. The three or four letters learned that week were reviewed briefly, with the majority of the review lesson devoted to a shared alphabet book reading. This format ensured equivalent amounts of exposure to each individual letter across the study and allowed for unbiased comparisons across letters with different letter name structures. Eight different commercially-available alphabet books were selected, one per review lesson/ instructional week. Each book included all 26 letters, with a page devoted to each individual letter and its corresponding sound. Each page displayed an enlarged uppercase form of the letter along with text emphasizing a target word beginning with the corresponding letter sound (e.g., A for Atlantic Ocean). The implementer stated each letter name and/or sound, inviting the children to also participate, and read the target word and text (see sample lesson in Appendix). When the target word did not begin with the sound children were intended to learn (e.g., A for armadillo), the researcher replaced the text and picture to reflect the appropriate sound (e.g., A for alligator).

Control/Number condition—Children in the control condition received number identification instruction. Similar to the alphabet instruction conditions, a curriculum consisting of 34 10- to 15- min lessons was provided. Sixteen lessons were devoted to instruction on a particular number, 0 to 15, with one to three individual number lessons provided each week. To equate on number of lessons and total instructional time, children in the number condition received 18 review lessons. Number lessons were designed to be as similar as possible to alphabet lessons in format, activities, intensity, and duration.

Makeup lessons—Fifty of the 58 children were absent for at least one lesson, and makeup lessons were provided whenever possible. Neither the number of absences nor the number of makeup lessons provided differed among conditions, $F(2, 57) = 0.37$, $p = .690$ and $F(2, 57) = 0.22$, $p = .801$ respectively.

Measures

Children's backgrounds/demographics, alphabet knowledge, and phonological processing skills were assessed as part of a larger assessment battery (Author, in press). All assessments were administered by trained research assistants blind to the conditions to which the children were assigned. Administration often occurred over multiple sessions, depending on the needs of individual children.

Children were initially screened in August, using the letter name production task. Participating children were pretested on all listed measures during the three weeks preceding the start of instruction, in late August/early September, and posttested on the alphabet and phonological processing tasks at the conclusion of the instructional period, during three weeks in late November and early December. Administration of the screening assessment required less than 20 minutes, while the pretest and posttest assessments required approximately one hour.

Background/demographics—Parent/guardian surveys were distributed with consent forms and used to collect demographic and background information on participating children. Parents were asked to indicate their child's full name, gender, and date of birth, and confirm that the child was a native speaker of English. Parents/guardians were also asked to indicate the highest level of education they had attained.

Children's verbal abilities were measured at the beginning of the study using the Receptive One-Word Picture Vocabulary Test (ROWPVT; Brownell, 2000). Children are shown color pictures of a number of objects and asked to point to the object named by the assessor (internal consistency, α = .96 for 4-year-olds). Standard scores (*M* = 100, *SD* = 15) are reported for descriptive purposes.

Alphabet knowledge—Letter name and sound knowledge were assessed by asking children to give the name and sound of each uppercase letter as presented on flashcards (Cronbach's α = .97 and .96 respectively; Wagner et al., 1994; Cronbach's α averaged .78 and .84 for letter name and sound tasks, respectively, in the present sample). Letters were presented in a different random order for each child, and the order in which the letter name and sound tasks were administered was counter-balanced across children at posttest. Responses to individual letters were scored dichotomously, with 1 representing a correct response and 0 representing an incorrect response. For the letter sound task, scoring was consistent with the sounds taught during alphabet lessons (regardless of whether a given child experienced alphabet instruction as part of the study). Thus, for example, a child providing the sound /s/ for the letter C was prompted to respond with an additional sound for C. The sound /s/ was considered incorrect.

Phonological processing skills—Children's phonological awareness/processing skills were assessed using the Test of Preschool Emergent Literacy (TOPEL; Lonigan, Wagner, Torgesen, & Rashotte, 2007; α = .85). The Phonological Awareness subtest of the TOPEL assesses phonological processing skill or the ability to manipulate sounds. The subtest involves two tasks, phonological elision and phonological blending. Both tasks progress from working with larger phonological units (i.e., whole words in compound nouns) to smaller units (i.e., syllables, rimes, phonemes). In the elision task, children are asked to provide the word that results when a portion of a given word is removed (e.g., *Sunflower* without *flower* is *sun*). The blending task asks children to provide the word that results when phonological segments are blended together (e.g., *Star—fish* makes *starfish*). Raw scores were used in analyses, with standard scores (*M* = 100, *SD* = 15) reported for descriptive purposes.

Number identification—As a check on the effectiveness of number training provided to the treated control, children's abilities to identify numbers was assessed using a task adapted from Malofeeva et al. (2004). Children were asked to name each number from 0–15, as presented on randomly ordered flashcards (α = .85). The number of correct responses was summed.

Letter Name Structure

Letters were grouped into CV (B, D, J, K, P, T, V, Z), VC (F, L, M, N, R, S, X), or NA (C, G., H, Q, W, Y) consonant categories in accordance with Treiman et al. (1997; 1998) and the sounds taught in the present study (e.g., C was included in the NA category because children were taught to associate C with the sound /k/ during instruction). A fourth and final category consisted of all vowels.

Multilevel Analysis

With the exception of preliminary analyses, multilevel models were used to correctly model the crossed nature of the data (letters crossed with children) and partition the variance into that due to differences across letters and that due to differences across children. More specifically, cross-classified random effect models were utilized (CCREM; Raudenbush & Bryk, 2002). Use of a CCREM not only allows results to be interpreted as reliable across both letters and children, but also allows for interactions between the properties of individual letters (e.g., letter name structure) and child characteristics (e.g., phonological processing ability) given the CCREM's multilevel structure (see Van den Noortgate, De Boeck, & Meulders, 2003 for further discussion of CCREM analysis with item and person data).

The CCREM for the present study included the dependent variable (i.e., the ability to identify letters by name or sound) at Level-1. Such knowledge was cross-classified at Level-2 by children (Level-2 rows) and letters (Level-2 columns). The model was fit using the Bernoulli distribution at Level-1, given the dichotomous nature of the outcome (i.e., 1 for a correct response to a given letter, 0 for an incorrect response). Thus, the unconditional model was represented as follows:

$$\begin{aligned}&\text{Prob}\ (Y_{ijk}=1 \mid B_{ijk})=\varphi_{ijk}\\&\log\left[\frac{\varphi_{ijk}}{1-\varphi_{ijk}}\right]=\eta_{ijk}=B_{0\,jk}\end{aligned}\qquad\text{(Level - 1 Model)}$$

$$B_{0\,jk}=\theta_0+b_{00\,j}+c_{00\,k}\qquad\text{(Level - 2 Model)}$$

In the model, φ_{ijk} is the probability that a child, with child characteristics j, will know a letter, given letter properties k and child X letter specifics i. $B_{0\,jk}$ is the log-odds of φ_{ijk} , which is a function of the mean log-odds (θ_0) plus the main random effects of child specific characteristics ($b_{00\,j}$) and letter specific characteristics (c_{00k}). Initial analyses indicated that the majority of variance in alphabet outcomes was due to individual differences among children ($b_{00\,j}$; 73.61% to 77.34% of the combined child and letter variance) as opposed to differences among letters (c_{00k} ; 22.66% to 26.39% of the combined variance). All variance components, however, were significantly greater than zero, statistically supporting the use of the CCREM.

Separate CCREMs were fit for letter name and letter sound knowledge. Two sets of models were analyzed, both of which involved interactions between letter properties and child characteristics. The types of letters that children learned as a result of instruction were investigated via the interaction between study condition and letter name structure. Dummy codes were created to represent the three training conditions (combined letter name and sound, letter sound only, number) and the four types of letter name structure (i.e., CV, VC, NA, and vowels). Specification of two-way interactions resulted in 12 interaction codes (e.g., combined-CV, sound only-CV, number-CV, combined-VC, etc.) used in analyses. Significant interactions between letter name structure and study condition indicated whether the learning of CV, VC, and NA letters was different across the combined letter name and sound, letter sound only, and number conditions. The second set of models explored the role of phonological processing skill in learning the three types of letters. The condition X letter name structure interaction codes were interacted with children's phonological processing scores (centered at the sample mean), retained as a continuous variable. Significant three-way interactions indicated that the relative likelihoods of learning CV, VC, and NA letters depended not only on the instructional condition to which children were assigned, but also the phonological abilities each brought to the task of alphabet learning. In all analyses, screening (letter name knowledge) or pretest (letter sound knowledge) scores were included as covariates to model residualized gain, and interpretation was made for children who learned a given letter (i.e., scored 0 at screening/pretest and 1 at posttest).

CCREMs were estimated using HLM6 software (Raudenbush, Bryk, & Congdon, 2008). Results were interpreted similarly to typical logistic regression models (Raudenbush & Bryk, 2002; Tabachnick & Fidell, 1996). Significant coefficients represented reliable effects of variables, and models were evaluated using the logistic function:

$$\text{Prob}(Y_{ijk}=1 \mid B_{ijk})=\varphi_{ijk}=\frac{1}{1+e^{-(B_{0\,jk}+B_{1\,jk}+B_{2\,jk}\ldots+B_{ijk})}}$$

The models thus give the probability (φ_{ijk}) of correctly responding to a given letter. B_{0jk} to B_{ijk} represent the Level-1 regression coefficients from the logistic model, which may include the effects of Level-2 variables (denoted by γ_{jk}). Although results are discussed in terms of probabilities for ease of reporting, coefficients may also be converted to log odds values using the formula e^{Bijk}. Likewise, probabilities may be converted to log odds using the formula:

$$\eta_{ijk}=\ln\frac{\varphi_{ijk}}{1-\varphi_{ijk}}$$

Again, φ_{ijk} represents the probability, while η_{ijk} represents the log odds value.

Given the use of dummy codes to represent the factors of condition and letter name structure, together with the two- and three-way interactions including these dummy-coded variables, a large number of coefficients were required to fully specify contrasts within each factor. Hence, statistics are provided in-text only for statistically significant results relevant to the present research aims. Full CCREM results are available from the first author upon request.

Results

Preliminary Analyses

Descriptive statistics for children's pretest and posttest scores in each of the intervention conditions are reported in Table 1. Preliminary analyses indicated that children in the three conditions did not differ on any demographic characteristics (i.e., gender, ethnicity, age, average parent education) or pretest scores, *p*s > .340. Repeated measures analyses showed that children in the number condition learned significantly more numbers than children in either the combined letter name and sound or letter sound only conditions, *p*s < .004.

Fidelity—Average fidelity was 98% (*SD* = 5.87) across implementers. Letter names were erroneously given in four letter sound only lessons (less than 3% of all letter sound only lessons). Planned pairwise comparisons using Dunnett's T3 procedure (Maxwell & Delaney, 2004) indicated no significant differences in fidelity across instruction conditions ($t[40.24] = 0.51$, $p = .938$ for combined letter name and sound versus letter sound only conditions, $t[40.24] = -1.68$, $p = .272$ for combined letter name and sound versus number conditions, $t[40.24] = -2.51$, $p = .051$ for letter sound only versus number conditions). Fidelity ratings were high (100%, 99%, and 94%), although the lowest fidelity rating was significantly different from the other two, *p*s < .033. The implementer with the lowest fidelity also mistakenly provided letter names during four letter sound only only lessons with the other implementers only erring once each. Dummy codes representing implementer were used as covariates in all analyses to account for these differences.

Nested nature of the data—The study was carefully designed to ensure that children's classrooms, teachers, and schools were not confounded with the three conditions in the study, via random assignment at the child level and the block randomization technique. Additionally, hierarchical linear models (HLM; Raudenbush & Bryk, 2002) revealed minimal, nonsignificant shared variance among small instructional groups for both alphabet outcomes (intraclass correlations < .019 conditional on pretest scores and implementer). All analyses were thus conducted at the child level.

Impact of Instruction on Types of Letters Learned

Table 2 presents the probabilities of correct responses to CV, VC, NA, and vowel letters across instructional conditions and outcomes. Comparisons of interest for these analyses were (1) reliable differences across letter types within conditions (e.g., CV versus NA letters within the combined letter name and sound condition) and (2) reliable differences across conditions within letter types (e.g., combined letter name and sound versus letter sound only conditions for CV letters). None of these comparisons were statistically significant when considering children's letter name learning.

For letter sound knowledge, comparisons across letter types but within conditions showed that children were generally least likely to learn the sounds of NA letters and most likely to learn the sounds of CV letters and/or vowels in the combined letter name and sound and number conditions. Specifically, within the combined letter name and sound condition, CV and VC letter sounds were more likely to be known than NA letter sounds ($\gamma = 1.62$, $t[1492] = 2.65$, $p = .009$ and $\gamma = 1.25$, $t[1492] = 1.98$, $p = .048$, respectively), with no differences in the likelihoods of knowing CV and VC letter sounds ($p = .482$) or vowel sounds and any of the consonant sounds (ps > .057). In the number condition, CV sounds and vowel sounds were more likely to be known than VC ($\gamma = 1.93$, $t[1492] = 2.19$, $p = .028$ and $\gamma = 1.85$, $t[1492] = 2.37$, $p = .018$, respectively) and NA ($\gamma = 1.864$, $t[1492] = 2.37$, $p = .018$ and $\gamma = 1.88$, $t[1492] = 2.24$, $p = .025$) letter sounds, with no significant differences in the likelihoods of knowing the sounds of CV letters versus vowels ($p = .976$) or VC versus NA letters ($p = .973$). Within the letter sound only condition, the likelihood of knowing VC letter sounds was significantly greater than knowing NA letter sounds ($\gamma = 1.797$, $t[1492] = 2.424$, $p = .016$), with no further differences among letter types (ps > .056).

When comparing across conditions, trends generally favored children in the combined letter name and sound condition. However, no significant differences emerged in the likelihoods of learning the sounds of CV letters (ps > .066), NA letters (ps > .125), or vowels (ps > .262). Children in the combined letter name and sound and letter sound only conditions were more likely to know the sounds of VC letters than children in the number condition ($\gamma = 2.56$, $t[1492] = 3.20$, $p = .001$ and $\gamma = 2.49$, $t[1492] = 3.20$, $p = .002$, respectively). Additional pairwise analyses involving between-condition and between-letter type comparisons also showed reliable differences for letter sound learning (e.g., combined letter name and sound CV learning > number NA learning) and are included in Table 2 for the interested reader as they do not bear on the present research aims. Overall, given the large number of interaction terms, only the advantages for VC letters in the combined letter name and sound and letter sound only conditions over the number condition, and the advantages for CV letters in the combined letter name and sound condition over VC and NA letters in the number condition, remained significantly statistically significant once error rates were adjusted using the linear step-up procedure (Benjamini & Hochberg, 1995;Kesselman, Cribbie, & Holland, 1999).

Relations with Phonological Processing

None of the condition X letter name structure X phonological processing skill three-way interaction terms were significant when predicting children's letter name knowledge (ps > .107). Main effects of phonological processing were also non-significant when predicting letter name knowledge ($p = .985$).

Three-way interactions were apparent for letter sound outcomes. Letter sound interactions are depicted in Figure 1, with phonological processing at the mean +/− 1 *SD*. Both slopes and intercepts were of interest in these interactions. Slopes indicated the strength of relations between phonological processing and the learning of particular types of letters. Figure 1 shows that these relations were generally positive across all letter types in the combined letter name and sound condition, and also positive for CV and vowels in the number condition. [2] Relations between phonological processing and the learning of particular letter types were more ambiguous in the letter sound only condition, with some slightly positive and some slightly negative relations. To further examine these relations, we tested whether the strength of the relations between phonological processing and letter sound learning differed among letter types within condition or within letter type across conditions. Significant differences emerged in three comparisons. Within the number condition, phonological skills were more highly related to the learning of CV letters than VC letters ($\gamma = -0.35$, $t[1480] = -2.47$, $p = .014$). Trends similarly favored stronger associations with the learning of CV letters over NA letters, and vowels over VC and NA letters but these did not meet traditional levels of significance, ps < .10. Comparing across letter types, phonological skills were more highly related to the learning of CV letters in the number condition than in the letter sound only condition ($\gamma = -0.32$, $t[1480] = -2.42$, $p = .016$). No further differences in the strength of relation between phonological processing and letter sound learning were found, ps > .148.

Intercept differences were examined to determine whether children of varying levels of phonological processing abilities also varied in their learning of CV, VC, and/or NA letter sounds. We compared the CV, VC, and NA point estimates shown in Figure 1 and listed in Table 3, for children with higher (+1 *SD*) and lower (−1 *SD*) phonological processing skills. Within the combined letter name and sound condition, children with lower phonological abilities were more likely to learn the sounds of VC letters than NA letters, $\gamma = 2.09$, $t(1480) = 1.98$, $p = .048$. A similar trend favored CV letters over NA letters, $\gamma = 1.99$, $t(1480) = 1.91$, $p = .056$. The advantage for learning CV over NA letters was more pronounced for children of higher phonological abilities, $\gamma = 1.53$, $t(1480) = 2.72$, $p = .023$.Within the letter sound only condition, despite trends favoring the learning of VC letters over NA letters (ps < .068), children were no more or less likely to learn the sounds of letters with varying letter name structures, regardless of phonological skill (ps > .060). Children in the number condition with lower phonological abilities also showed no differences in learning the three consonant types (ps > .646). Children with higher phonological abilities, however, showed an advantage in learning CV letter sounds over NA and VC sounds, $\gamma = 2.48$, $t(1480) = 2.65$, $p = .009$ and $\gamma = 3.08$, $t(1480) = 2.93$, $p = .004$. Vowel sounds showed a similar advantage for these children, $\gamma = 2.35$, $t(1480) = 2.37$, $p = .018$ and $\gamma = 2.95$, $t(1480) = 2.68$, $p = .008$. Additional comparisons across conditions but within letter types showed (1) no differences between conditions in the learning of NA letters regardless of phonological abilities (ps > .183), (2) an advantage in learning CV letters in the combined letter name and sound and letter sound only conditions over those in the NA condition for children with lower phonological abilities ($\gamma = 2.54$, $t[1480] = 2.19$, $p = .029$ and $\gamma = 2.29$, $t[1480] = 2.06$, $p = .039$ respectively) but not higher phonological abilities (ps > .187), (3) an advantage in learning VC letters in the combined letter name and sound and letter sound only conditions over those in the NA condition for children with higher phonological abilities ($\gamma = 2.94$, $t[1480] = 2.569$, $p = .011$ and $\gamma = 3.02$, $t[1480] = 2.60$, $p = .010$) and a similar trend for children with lower phonological abilities in the combined letter name and sound condition ($p < .080$). Note that the large number of interaction terms prevented any of these comparisons from meeting adjusted significance levels once the linear step-up procedure was applied.

Discussion

The present study yielded several results with implications for understanding children's letter acquisition. First, our results showed that letter name structure had little effect on the learning of letter names. Second, our results for letter sound learning were largely consistent with the letter name-to-sound effect: Children receiving combined letter name and sound instruction

[2]HLM6 software does not provide omnibus tests for interactions, nor are the estimation procedures for non-linear CCREMs currently available in HLM6 capable of providing appropriate deviance statistics for model comparisons (Scientific Software International, n.d.). In this analysis, the general presence of interactions is indicated by the existence of significant condition X letter type X phonological processing interaction terms, regardless of the specific conditions and letter types involved. As in any nominal X continuous variable interaction, significant interaction terms are interpreted as representing a reliable difference in slope between the nominal group(s) of interest and the reference group (Cohen, Cohen, West, & Aiken, 2003).

showed accelerated letter sound learning of CV and VC letters. Moreover, letter name-to-sound and training effects were moderated by children's phonological processing abilities. The latter is of considerable practical importance, as provision of explicit letter name and sound instruction overrode phonological processing limitations in promoting letter sound development.

Letter Name Learning

Results showed that children's learning of CV, VC, NA, and vowel letter names was not different across training conditions, indicating that letter name structure did not affect letter name learning. These findings are consistent with studies by Treiman and colleagues (Treiman & Broderick, 1998; Treiman et al., 1998).They conflict, however, with findings by McBride-Chang (1999) and Justice et al. (2006) in which consonants whose names included their sounds were more likely to be correctly named by children. The discrepant results in the present study may be due to the difference in analyzing children's static knowledge versus learning. Additionally, while the letter name-to-sound hypothesis sets forth a mechanism by which letter name structure affects sound acquisition, theoretical explanations relating letter name structure and letter name learning are not clear. The remainder of our discussion is devoted to further understanding the impact of combined letter name and sound instruction on letter sound learning, as premised on the letter name-to-sound facilitation effect.

Effects of Letter Name Structure on Letter Sound Learning

Of particular interest in this study was an examination of the letter name-to-sound effect on children's letter sound learning. The general pattern of results was consistent with many of our original hypotheses concerning this effect. As hypothesized, children taught both letter names and sounds learned the sounds of CV and VC letters to a greater extent than they learned NA letters (25.4% and 19.0% versus 6.3% chance of learning). This pattern of learning was reliable across children of all levels of phonological processing abilities, which were positively related to letter sound learning for all letter types. These results are largely consistent with a causal interpretation of the letter name-to-sound facilitation effect as presented in past correlational research (Evans et al., 2006; McBride-Chang, 1999; Treiman et al., 1998). Interestingly, the advantage of CV over VC letters demonstrated in correlational studies was not evident in the present sample; children had a greater tendency to learn those letters whose names included cues to their sounds regardless of whether the sounds were represented at the beginning or end of the letter name. A similar result was reported by Share (2004).

In contrast to children who experienced combined letter name and sound instruction, the letter sound learning of children in the number condition varied according to phonological processing abilities (Share, 2004; c.f. de Jong, 2007; Treiman et al., 2008). Recall that these children did not receive explicit instruction in letter sounds; the results for children in this condition ought to be interpreted as reflecting the typical learning of preschoolers. Within this condition, children with lower phonological abilities demonstrated very low probabilities of learning the sounds of any letters (1.6%, 3.2%, and 1.8% for CV, VC, and NA letters, respectively) with no reliable differences among letter types. Children with higher phonological abilities, however, were more likely to learn the sounds of CV (25.5%) and vowels (23.2%) as opposed to VC (1.6%) or NA (2.8%) letters. The letter sound learning of these children was thus partially consistent with the letter name structure effect. While an advantage for VC letters would be expected to completely replicate the results of most previous studies, equivalence in learning VC and NA letter sounds is not unprecedented. Both Treiman et al. (1998) and McBride-Chang (1999) found similar results for their youngest samples and/or earliest assessment points. An explanation for these findings concerns the relative ease of learning CV, VC, and NA letters as related to the letter name structure hypothesis. For CV letters, the corresponding letter sounds occur at the beginning of the letter name, perhaps making these sounds more salient than those in VC letter names. This may be particularly true for very young children (Treiman et al., 1997) whose levels of phonological skill may make segmenting initial sounds/onsets easier than segmenting rimes (Anthony, Lonigan, Driscoll, Phillips, & Burgess, 2003). The sound cue at the end of the VC letter names may be difficult for young children to isolate, making these letters more akin to NA letter names from which the sound cannot be extracted. Without instruction, then, the learning of CV letter sounds may occur relatively easily and perhaps implicitly for young children, while the learning of VC letter sounds requires either explicit instruction or more advanced phonological abilities. This interpretation is consistent with results favoring children receiving letter sound instruction over those in the number condition on VC sound learning. It is also supported by the strong positive relation between phonological processing and CV letter sound learning for children in the number condition. This relation, combined with the results reported above, suggests that in the absence of explicit letter sound instruction, only those children with higher phonological abilities are capable of segmenting the initial sounds from CV letter names and using these as cues to letter sounds. In comparison, the extraction of the sound cue at the end of VC letter names required either explicit instruction or even more advanced phonological skills than were possessed by the young children in this sample.

An additional interesting point concerning the letter sound acquisition of children in the number condition is the high likelihood of learning vowel sounds. This result is consistent with earlier findings showing that children are often highly familiar with vowel sounds (Evans et al., 2006; Treiman et al., 1998) and expands work by Evans et al., to demonstrate that this greater familiarity exists even when only short vowel sounds are considered. We offer two preliminary explanations for this finding. First, if children are indeed more adept at learning vowel sounds, this may stem from better phonological representations of such sounds (Justice et al., 2006) given that vowel sounds are produced by children at a much earlier age than consonant sounds (Sander, 1972). Second, this finding may be a result of exposure or attention to vowels in the absence of explicit sound instruction. In particular, young children have been shown to be especially familiar with the letter A (McBride-Chang, 1999; Treiman & Kessler, 2003; Treiman et al., 2006) given its primary position within the alphabet, reference to the alphabet as the ABCs, and instruction that often proceeds in alphabetic order. Post hoc examination in the present study revealed that greater learning of vowel sounds in the number condition may have been an artifact of their familiarity with the letter A rather than a general vowel effect: (a) letter A was one of the most frequently learned letters for children in the number condition and (b) vowels were no more or less likely to be learned in comparison to other types of letters when letter A was removed from analyses. Further studies of young children's vowel sound acquisition are need to empirically test this and other explanations.

The results for children who received only letter sound instruction differ markedly from those presented above. Children in the letter sound only condition demonstrated letter sound learning at odds with the typical letter name structure effect. Instead, children in the letter sound only condition were significantly more likely to learn VC letter sounds (18.0% chance) than either CV (11.1%) or NA (3.5%) sounds. Moreover, letter sound acquisition, letter name structure, and phonological processing were unrelated for children in this condition, with the main effect for VC letters disappearing once phonological processing skills were taken into account (i.e., no significant differences among letter types for children with lower or higher phonological abilities). Although an explanation for a VC advantage is unclear and deserves further investigation, the null findings involving phonological processing X letter name structure interactions are consistent with hypotheses regarding the letter name-to-sound facilitation effect. Children in this condition were not taught letter names from which to derived sound cues for CV and VC letters, and showed significantly lower letter name knowledge than children receiving letter name and sound instruction at the end of the study.

Practical Implications

The results of this study are particularly relevant to educational practice for a number of reasons. Learning gains, not static knowledge, were examined, and, as opposed to previous correlational work, greater gains within the letter name and sound condition can be directly attributed to the instruction provided. Confidence in the latter is particularly high for this study, as (1) random assignment equated conditions in the skills and knowledge children initially brought to the task of alphabet learning and (2) the instruction provided was not confounded with implementer, schools, classrooms, or teachers. Given our concern for ecological validity, these two points are particularly important. It is unlikely that three- and four-year old children would be unfamiliar with all letters and also unlikely that parents and childcare/preschool providers would refrain from referring to the alphabet for the duration of a study. Random assignment of children, blocked within centers and classrooms, ensures that these factors are randomly distributed across conditions, rendering estimates of effect unbiased (Shadish, Cook, & Campbell, 2002). Of additional import is the ecological validity of the instruction provided. We offered alphabet instruction suitable for preschool-aged (Berk & Winsler, 1995; National Research Council, 1998; Ohio Department of Education, 2005) and delivered this instruction within the preschool setting using a realistic child:implementer ratio (i.e., small groups) (c.f. Levin et al., 2006; Share, 2004; Treiman et al., 1998). Altogether, the type of instruction delivered was both commensurate with practices predictive of greater early literacy development (e.g., Connor, Morrison, & Slominski, 2006) and those practices one might hope to see in high quality early childhood settings.

One instructional implication supported by our findings concerns the utility of letter name instruction in those cultures in which letter names are commonly utilized (c.f. Caravolas, Hulme, & Snowling, 2001; Ellefson, Treiman, & Kessler, 2009). Our findings are contrary to suggestions that letter name instruction is unimportant or, worse, detrimental for children's letter sound acquisition (Groff, 1984; McGuinness, 2004; see also Adams, 1990, pp. 350–355). These assertions have been founded on the notion that letter name and letter sound knowledge are not causal in nature, with letter name knowledge merely indexing other factors related to early literacy such as print awareness and exposure, socioeconomic status, parental involvement, and so forth (Foulin, 2005). Such beliefs have prompted approaches for teaching early literacy that disregard letter names altogether (Gurney, 1999; Jolly Learning Ltd., n.d.; Montessori & Gutek, 2004). The experimental design of the present study counters this argument, showing that letter name training, when combined with sound instruction, may causally impact students' letter sound acquisition.

Our results suggest that early childhood educators consider teaching both letter names and sounds simultaneously rather than focusing solely on sound instruction. Overall trends tended to favor children in the combined letter name and sound condition, although we caution that further intervention work yielding larger effects and greater statistical power is warranted. Letter name and sound instruction appeared to accelerate children's letter sound acquisition without altering established developmental trends in the types of letter sounds likely to be learned (i.e., the letter name structure effect seen in typical preschool learning, as demonstrated in the number condition as well as previous correlational research). Provision of instruction merely increased children's knowledge of letter sounds, and expanded the letter name structure effect to apply to VC as well as CV letters.

Providing letter name and sound instruction appeared to override the limitations of phonological processing in learning letter sounds. This interpretation is supported by results showing that all children receiving such instruction learned letter sounds, regardless of phonological abilities, and that children with both lower and higher phonological abilities showed advantages in learning the sounds of both CV and VC over NA letters. These results stand in stark contrast to those for children who did not experience letter sound instruction.

These children were highly unlikely to learn any letter sounds if their phonological abilities were low, and tended to learn only CV letters even with higher phonological abilities. The tendency for children with lower phonological processing abilities who received letter name and sound instruction to learn CV and, more importantly, VC letters indicates that these children were able to take advantage of the letter name-to-sound effect to its fullest extent (note that although children receiving only letter sound instruction also tended to learn VC letters, their learning patterns were not consistent with letter name-to-sound facilitation, particularly once phonological abilities were taken into account, as described above). Altogether, these results imply that alphabet instruction may be particularly important for young children at-risk for reading failure due to phonological deficits, as these children appear unable to use letter name structure to extract letter sound information on their own. As supported by additional research on child X instruction interactions (Connor et al., 2006; Connor et al., 2009; Foorman, Francis, Fletcher, Schatschneider, & Mehta, 1998; Juel & Minden-Cupp, 2000), early childhood educators may need to vary their alphabet instructional practices according to the skills with which children enter their classrooms. For children entering with lower phonological abilities, explicit instruction in letter sounds may be particularly critical for ensuring adequate development in this domain of emergent literacy.

Limitations and Future Directions

One limitation of the study concerned the intensity with which alphabet knowledge was taught. Although “letter-a-day” approaches are common in early childhood settings (e.g., McGill-Franzen, Lanford, & Adams, 1997; Pressley, Rankin, & Yokoi, 1996; Slavin, 1999), the intensity and duration of instruction provided in the current study produced only relatively modest gains in children’s alphabet knowledge. Alphabet teaching affording greater instructional time, more frequent opportunities for repetition and practice, and/or better integration with regular classroom activities may well lead to greater impacts than those reported here. Additionally, effects of instruction may have been larger for children of pre-kindergarten age as opposed to the young sample used in the present study. Future design work might address how such instructional features and/or other letter properties and child characteristics affect children’s letter sound learning. The study also could not control for exposure to letter names outside the training context. Although such effects were randomly distributed across conditions leading to unbiased impact estimates, future studies might assess such exposure for inclusion in analyses or include an additional condition in which only letter names are taught in order to better understand the interplay between instruction and exposure in letter name learning. Given the relative innovation of combining these letter and child factors into a single, multilevel analysis, replication of these results with independent samples is also desirable. Finally, the development of letter name and sound knowledge are not ends in and of themselves; our efforts to better understand alphabet acquisition and instruction are aimed at facilitating later literacy development. Future work ought to continue to identify the best means of fostering alphabet knowledge and investigate the longitudinal effects of offering effective alphabet instruction on prevention of reading and spelling difficulties. We hope that the current findings concerning letter name-to-sound facilitation and the relative effectiveness of combined letter name and sound instruction are used to inform such endeavors.

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Appendix

Combined Letter Name and Sound Condition

Individual Letter Lesson

Place ABC mats in front of each child. Place pile of magnetic letters in front of children. Show children *B* flashcard and put on magnetic board. **Here is the letter *B*. It makes the sound /*Bə*/. Everyone find a letter *B* from the pile. Show me your letter. What is it called?**

Point to the letter mats. **Everyone put your finger on the letter *B* on your mats. Watch me trace my letter *B*.** Trace the letter *B* on the flashcard. **Let me see you use your finger to trace the letter *B* on your mats.**

The letter *B* says /Bə/. Let me hear you say /Bə/. What picture is above the letter *B* on your mats (*bear***)? That's right,** bear (or, **That's a** bear). Place the word Bear on the magnetic board. Bear **starts with the /Bə/ sound.** B—ear **(emphasis /Bə/ sound).** Bear **starts with the letter *B*, see?** Point to *B* at beginning of the word. **Let me hear you say /Bə/ for** bear.

Take out stack of *B* picture cards (*butterfly, balloons, banana, baby, basket, ball, bells, books*). **Let's play a game. What is this?** Help children name each picture as you place them in front of them. To each child individually: **Show me one that starts with the /Bə/ sound. That's right, _____ starts with the /Bə/ sound because it starts with the letter *B*. Let me hear you say /Bə/ for _____.** Put the written word on the magnetic board. **Show me the letter *B* in the word _____. Let me hear you say *B*. Put your *B* on the *B* in the word _____.** Help the child cover the letter in the written word with their magnetic letter. Repeat the picture card game for each child in the group.

After each child has a turn, hold each of the remaining *B* picture cards one at a time. **This is _____. Does it start with the /Bə/ sound? Yes it does.** Put the written word on the magnetic board. **What letter does _____ start with?** Point to the letter *B* at the beginning of the word. **_____ starts with the /Bə/ sound because it starts with the letter *B*. Let me hear you say /Bə/ for _____.**

Nice job today! You can all have a sticker for working so hard. To each child individually: **Come find the letter we learned about today.** Let child find *B* sticker on sheet. **What do we call this letter? What sound does it make?** Repeat with other children as lining them up.

**Redirects/prompts may used throughout the lesson to maintain the children's attention.

Review Lesson

Place ABC mats in front of each child. Put flashcards of letters learned that week on magnetic board. **Look at all the letters we learned this week!** Pointing to the first letter say, **We learned that the letter (*letter name*) says /*sound*/. Point to the letter (*letter name*) on your mat. Let me hear you say (*letter name*). Let me hear you say /*sound*/.** Repeat for other letters taught that week.

We're going to read a book called (*title of book*).

When reading the book, start each page by pointing to the letter and saying its **name and sound** (e.g., point saying *K*, /*K*/). Encourage the children to repeat you. Read the text on the page, referring to the letter by **name**. At the end of the page, point to the letter again and say **its name and sound** (the children do not need to repeat it a second time).

Praise the children for their work that week. Give each a sticker and line up.

**Redirects/prompts may used throughout the lesson to maintain the children's attention.

Letter Sound Only Condition

Individual Letter Lesson

Place ABC mats in front of each child. Place pile of magnetic letters in front of children. Show children *B* flashcard and put on magnetic board. **Here is the letter for today. This letter makes the sound /Bə/. Everyone find a letter that says /Bə/ from the pile. Show me your letter. What does it say?**

Point to the letter mats. **Everyone put your finger on the letter that says /Bə/ on your mats. Watch me trace my letter /Bə/.** Trace the letter /Bə/on the flashcard. **Let me see you use your finger to trace the letter that says /Bə/ on your mats.**

This letter makes the sound /Bə/. Let me hear you say /Bə/. What picture is above the letter /Bə/ on your mats (*bear*)**? That's right**, bear (or, **That's a** bear). Place the word Bear on the magnetic board. Bear **starts with the /Bə/ sound.** B—ear **(emphasis /Bə/ sound).** Bear **starts with /Bə/, see?** Point to /Bə/at beginning of the word. **Let me hear you say /Bə/ for** bear.

Take out stack of *B* picture cards (*butterfly, balloons, banana, baby, basket, ball, bells, books*). **Let's play a game. What is this?** Help children name each picture as you place them in front of them. To each child individually: **Show me one that starts with the /Bə/ sound. That's right, _____ starts with the /Bə/ sound. Let me hear you say /Bə/ for _____.** Put the written word on the magnetic board. **Show me the /Bə/ in the word _____. Let me hear you**

say /Bə/. Put your /Bə/ on the /Bə/ in the word _____. Help the child cover the letter in the written word with their magnetic letter. Repeat the picture card game for each child in the group.

After each child has a turn, hold each of the remaining /Bə/picture cards one at a time. **This is _____. Does it start with the /Bə/ sound? Yes it does.** Put the written word on the magnetic board. Point to the letter /Bə/at the beginning of the word. **_____ starts with the /Bə/ sound. Let me hear you say /Bə/ for _____.**

Nice job today! You can all have a sticker for working so hard. To each child individually: **Come find the letter we learned about today.** Let child find /Bə/sticker on sheet. **What do we call this letter? What sound does it make?** Repeat with other children as lining them up.

**Redirects/prompts may used throughout the lesson to maintain the children's attention.

If a child gives the name of the letter, acknowledge and redirect: **Yes, that letter can also be called *B*, but we're going to call it /Bə/.

Review Lesson

Place ABC mats in front of each child. Put flashcards of letters learned that week on magnetic board. **Look at all the letters we learned this week!** Pointing to the first letter say, **We learned the letter that says /*sound*/. Point to the letter that says /*sound*/ on your mat. Let me hear you say /*sound*/.** Repeat for other letters taught that week.

We're going to read a book called (*title of book*).

When reading the book, start each page by pointing to the letter and saying its **sound** (e.g., point saying /*K*/). Encourage the children to repeat you. Read the text on the page, again only referring to the letter by **sound**. At the end of the page, point to the letter again and say its **sound** (the children do not need to repeat it a second time).

Praise the children for their work that week. Give each a sticker and line up.

**Redirects/prompts may used throughout the lesson to maintain the children's attention.

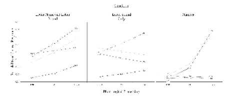

Figure 1.
Probabilities of correct responses on letter sound production task for children with phonological processing abilities at the mean (10.95) +/− 1 SD (5.34) in the three instructional conditions. CV = consonant-vowel; VC = vowel-consonant; NA = no association.

Table 1

Descriptive Statistics

	Full sample (n = 58)			Combined letter name and sound condition (n = 20)			Letter sound only condition (n = 20)			Number condition (n = 18)		
	M	***SD***	**Range**	***M***	***SD***	**Range**	***M***	***SD***	**Range**	***M***	***SD***	**Range**
LN screening	3.53	2.70	0 – 8	3.65	2.80	0 – 8	3.40	2.50	0 – 8	3.56	2.96	0 – 8
Pretest												
Parent education	5.53	1.12	1.00 – 7.00	5.73	0.88	4.00 – 7.00	5.14	1.54	1.00 – 7.00	5.71	0.71	4.50 – 7.00
Age (years)	3.77	0.62	2.77 – 5.00	3.70	0.65	2.77 – 5.00	3.78	0.56	2.79 – 4.86	3.83	0.66	2.97 – 4.95
LS	0.95	1.88	0 – 9	0.90	2.02	0 – 7	1.05	2.06	0 – 9	0.89	1.57	0 – 5
Voc SS	98.29	11.36	64 – 125	100.40	9.80	85 – 119	95.50	10.80	64 – 108	99.06	13.42	77 – 125
PA raw score	10.95	5.34	0 – 23	11.20	5.15	1 – 22	10.60	5.88	0 – 23	11.06	5.20	2 – 21
PA SS	92.72	12.89	69 – 124	94.35	10.97	72 – 110	91.40	13.83	69 – 120	92.39	14.26	72 – 124
Number ID	2.84	3.10	0 – 10	2.75	3.19	0 – 9	2.50	2.78	0 – 8	3.33	3.43	0 – 10
Posttest												
LN	8.84	6.52	0 – 25	10.40	8.22	0 – 25	7.35	5.27	0 – 16	8.78	5.51	0 – 20
LS	3.03	4.42	0 – 20	4.35	5.98	0 – 20	2.60	3.44	0 – 15	2.06	3.00	0 – 9
PA raw score	13.28	4.43	3 – 27	13.90	4.23	7 – 21	12.80	4.46	3 – 21	13.11	4.79	7 – 27
PA SS	97.48	11.46	72 – 126	101.25	9.09	85 – 115	95.15	12.48	72 – 123	95.89	12.18	79 – 126
Number ID	5.19	4.11	0 – 16	4.85	3.54	1 – 11	3.75	3.40	0 – 11	7.17	4.81	0 – 16

Note. LN = letter name; LS = letter sound; Voc = Receptive One-Word Picture Vocabulary Test; SS = standard score; PA = Test of Preschool Emergent Literacy Phonological Awareness subtest; Number ID = number identification assessment.

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Table 2

Probabilities of Correct Responses on Alphabet Outcomes by Instructional Conditions and Letter Type

	Condition		
Letter Type	**Combined letter name and sound**	**Letter sound only**	**Number**
	Letter name knowledge		
Across all	0.34_{a}	0.20_{a}	0.27
CV	0.33	0.20	0.21
VC	0.38_{b}	0.20	0.29
NA	0.28	0.16_{b}	0.27
Vowel	0.38	0.26	0.33
	Letter sound knowledge		
Across all	0.17_{a}	0.11	0.05_{a}
CV	$0.25_{b\,c\,d\,e}$	$0.11_{f\,g}$	$0.10_{h\,i}$
VC	$0.19_{j\,k\,l\,m}$	$0.18_{n\,o\,p}$	$0.02_{d\,f\,h\,l\,o\,q\,r\,s}$
NA	$0.06_{b\,j}$	$0.04_{c\,k\,n\,t}$	$0.02_{e\,g\,i\,m\,p\,u\,v\,w}$
Vowel	$0.20_{q\,t\,u}$	$0.14_{r\,v}$	$0.10_{s\,w}$

Note. Probabilities with the same subscripts within each outcome differ significantly at $p < .05$. Results are for those children who learned given letters (i.e., scored 0 at screening/pretest and 1 at posttest). CV = consonant-vowel letter name structure (B, D, J, K, P, T, V, Z); VC = vowel-consonant letter name structure (F, L, M, N, R, S, X); NA = no association between letter names and sounds (C, G, H, Q, W, Y).

Table 3

Probabilities of Correct Responses on Letter Sounds by Instructional Conditions and Letter Type for Children with Phonological Processing at +/− 1 SD

	Condition		
Letter Type	**Combined letter name and sound**	**Letter sound only**	**Number**
	Phonological processing at −1 *SD*		
CV	0.17_{a}	0.14_{b}	0.02_{abcde}
VC	0.19_{cfg}	0.14_{d}	0.03_{f}
NA	0.03_{g}	0.03	0.02
Vowel	0.13	0.17_{e}	0.03
	Phonological processing at +1 *SD*		
CV	0.36_{abcde}	0.10_{a}	0.26_{fg}
VC	0.23_{hi}	0.24_{jk}	0.02_{bfhjlm}
NA	0.12_{d}	0.06_{c}	0.03_{egikno}
Vowel	0.29_{ln}	0.14	0.23_{mo}

Note. Probabilities with the same subscripts within each outcome differ significantly at $p < .05$. Results are for those children who learned given letters (i.e., scored 0 at screening/pretest and 1 at posttest). CV = consonant-vowel letter name structure (B, D, J, K, P, T, V, Z); VC = vowel-consonant letter name structure (F, L, M, N, R, S, X); NA = no association between letter names and sounds (C, G, H, Q, W, Y).