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# An investigation of four hypotheses concerning the order by which 4-year-old children learn the alphabet letters

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**Abstract**

This study tested four complementary hypotheses to characterize intrinsic and extrinsic influences on the order with which preschool children learn the names of individual alphabet letters. The hypotheses included: (a) *own-name advantage*, which states that children learn those letters earlier which occur in their own names, (b) the *letter-order hypothesis*, which states that letters occurring earlier in the alphabet string are learned before letters occurring later in the alphabet string, (c) the *letter-name pronunciation effect*, which states that children learn earlier those alphabet letters for which the name of the letter is in the letter's pronunciation, and (d) the *consonant-order hypothesis*, which states that children learn earlier those letters for which corresponding consonantal phonemes are learned early in phonological development. Participants were 339 four-year-old children attending public preschool classrooms serving primarily low-income children. Children's knowledge of each of the 26 alphabet letters was assessed, and these data were tested for the four hypotheses using a linear logistic test model (LLTM). Results from the LLTM confirmed all four hypotheses to show that the order of letter learning is not random, in that some letters hold an advantage over other letters to influence their order of learning. Implications for educational policy and practice are discussed.


*Keywords:* Alphabet knowledge; Early literacy development; Preschool education; At-risk children

## 1. Introduction

In the current context of educational policies that emphasize the importance of systematic and explicit phonics instruction in the early elementary grades (e.g., National Reading Panel, 2000), well-developed alphabet knowledge is considered a key kindergarten readiness skill (e.g., Lonigan, Burgess, & Anthony, 2000; Storch & Whitehurst, 2002). Assuredly, both theory and evidence point to a variety of additional language and literacy skills being valuable achievements during the years prior to formal schooling (e.g., vocabulary, narrative, print concepts, phonological awareness), yet most constituents agree that alphabet knowledge represents one of the most critical literacy skills that children can develop during the preschool years (see Adams, 2003). Accordingly, policy documents that provide direction to academic literacy curricula in preschool programs typically identify alphabet knowledge as a necessary focus of instruction. As one example, the Head Start Child Outcomes Framework (Administration for Children and Families, 2002) stipulates that by the end of preschool, children should identify "at least 10 letters of the alphabet, especially those in their name" and should show progress in "associating the names of letters with their shapes and sounds."

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This research examined the specific alphabet letters known by 4-year-old at-risk preschoolers to investigate four hypotheses specifying extrinsic and intrinsic influences on children's learning of individual alphabet letters: (a) the *own-name advantage*, which states that children learn those letters earlier which occur in their own names, (b) the *letter-order hypothesis,* which states that letters occurring earlier in the alphabet string are learned before letters occurring later in the alphabet string, (c) the *letter-name pronunciation effect,* which states that children learn earlier those alphabet letters for which the name of the letter is in the letter's pronunciation, and (d) the *consonant-order hypothesis*, which states that children learn earlier those letters for which corresponding consonantal phonemes are learned relatively early in phonological development. Research that examines influences on children's learning of the individual alphabet letters is necessary to further our theoretical understanding of this important developmental phenomenon and to inform future research as well as educational policies and practices pertaining to early literacy instruction.

### *1.1. Why alphabet knowledge is a topic of contemporary interest*

There are several reasons for the current political interest in ensuring young children's timely achievement of alphabet knowledge. First, a large empirical literature points to alphabet knowledge as being one of the strongest unique predictors of children's later reading achievement, particularly their word recognition skills (e.g., Catts, Fey, Tomblin, & Zhang, 2002; Lonigan et al., 2000; Muter, Hulme, Snowling, & Stevenson, 2004; Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004; Storch & Whitehurst, 2002). Hammill's (2004) recent study comparing the outcomes of three separate meta-analyses (comprising 452 studies) on preschool and kindergarten predictors of later reading ability showed alphabet knowledge to be one of only three predictor variables that exhibited a large effect size across all three meta-analyses. Similar conclusions will be reported in the forthcoming meta-analysis of the National Early Literacy Panel (Lonigan, 2004), which examined the relationship between specific early literacy skills and later reading achievement in its review of 234 studies. Like Hammill's study, the panel's review found alphabet knowledge to be one of the more robust and consistent predictors of children's later word recognition skills.

Second, the relationship between alphabet knowledge and later reading achievement appears to be causal in nature (Lonigan et al., 2000). More precisely, children's learning of letter-sound correspondences appears dependent upon their knowledge of letter names (McBride-Chang, 1999; Treiman, Tincoff, Rodriguez, Mousaki, & Francis, 1998), in that children use knowledge of letter names to learn their sounds (Treiman et al., 1998). In turn, children's knowledge of the correspondences between letters and sounds is both a fundamental and necessary precondition for developments in word recognition (e.g., Morris, Bloodgood, Lomax, & Perney, 2003; Storch & Whitehurst, 2002; Treiman et al., 1998). Alphabet knowledge thus represents a single unitary construct that is not only measurable and developmentally stable in young children (Lonigan et al., 2000), but that also appears a watershed event in facilitating children's future capabilities in reading development, particularly word recognition.

Third, alphabet knowledge is currently viewed as one of the most accurate identifiers of a young child's later risk for reading difficulties. Prospective longitudinal studies investigating precursors to risk for reading difficulties consistently show under-developed alphabet knowledge to be one of the most readily- and reliably-identifiable risk factors (e.g., Elbro, Borstrom, & Petersen, 1998; O'Connor & Jenkins, 1999). Here we provide two recent examples from this body of work. Gallagher, Frith, and Snowling's (2000) longitudinal study of children at genetic risk for dyslexia found alphabet knowledge at 45 months (from among a battery of 12 language and literacy measures) to be the strongest predictor of risk for dyslexia at 6 years; at 45 months, children eventually developing dyslexia knew an average of 2 letters, whereas those who achieved typical reading skills knew an average of 6 letters, corresponding to a large standardized difference ($d = 0.74$). Similarly, Catts et al.'s (2002) longitudinal study of 5-year-old children with language impairment (LI; an established risk factor for reading disability) also found alphabet knowledge to be the single best predictor of whether a child with LI would exhibit reading disability in second grade. Kindergarten performance on a measure of alphabet knowledge explained 27% and 25% of the variance in second-grade word recognition and reading comprehension scores, respectively.

To summarize, it is currently well established that alphabet knowledge is an important emergent literacy skill and that under-developed alphabet knowledge is an identifiable risk factor for later reading difficulty. As a developmental phenomenon, however, much less is known concerning how children go about learning the names of individual letters, although evidence suggests that there are systematic differences among letters that both support and constrain children's learning of them. Investigations seeking to identify specific factors that give rise to differences among letters in the order or ease with which children learn them are interesting for several reasons. Theoretically, a considerable literature

Table 1
Comparison of curricular approaches to teaching alphabet letters

| Preschool curriculum | Approach |
|---|---|
| Creative curriculum (Dodge, Colker, & Heroman, 2002) | Suggests that letters be taught beginning with letters in children's names, followed by letters in words that are important to them, such as "Mom", "Dad", and a pet's name |
| Frontline phonics (Frontline Educational Products, LLC, 2003) | The five most common letters (M, A, P, S, and T) are taught first so that children can begin to sound out words before knowing the entire alphabet |
| High/Scope (Hohmann & Weikart, 1995) | No information provided |
| Let's begin with the letter people (Abrams & Company Publishers, Inc., 2005) | Letters are taught through thematic units in the following sequence: N, W, P, H, M, A, B, K, D, F, O, C, E, Y, G, T, S, R, Z, I, Q, V, L, U, J, X |
| The language-focused curriculum (Bunce, 1995) | No information provided |
| Open Court Reading PreK (SRA/McGraw-Hill, 2003) | Letters are taught in alphabetical order, one letter per lesson. A review is conducted after four lessons until the alphabet is complete and then additional reviews are conducted of all alphabet letters |
| Waterford Early Reading Program (Waterford Research Institute, Inc., 2005) | Letters are taught in alphabetical order |

base is available that describes the emergence of specific language and literacy skills, including lexical (e.g., Jaswal & Markman, 2003; Schafer, 2005), phonological (e.g., Beckman & Edwards, 2000; Saffran & Thiessen, 2003), and syntactic abilities (e.g., Charity, Scarborough, & Griffin, 2004; Eisenberg, 2004). These lines of research show myriad factors to interact as both supports and constraints on children's learning of specific language units. For instance, research on lexical development shows that contextual factors significantly affect the ease with which a child learns new words (e.g., Bedore & Leonard, 2000), as do intrinsic factors related to the words themselves (e.g., phonological structure of the word; see Saffran & Thiessen, 2003).

Insights gained from developmental science are not only relevant to furthering our basic theories concerning children's literacy and language development, but also can inform and advance public policies and educational interventions designed to promote young children's development and learning. Of relevance to the present research is that relatively little developmental research has been conducted concerning children's emergent knowledge about the alphabet, despite clear indications that it serves as both a causal and robust predictor of later reading outcomes and is an area of keen relevance to current educational policy and practice. The relative dearth of research in this area is evident in the diversity of approaches to alphabet instruction in prevailing preschool literacy curricula, as shown in Table 1. As Table 1 shows, some curricula do not make explicit mention of instruction in alphabet letters, whereas others advocate a specific order of instruction in alphabet letters, such as teaching the letters in alphabetical order or teaching high-frequency letters first.

Research that adds precision to our understanding of children's alphabet learning should ultimately improve both educational policy and instructional practices that relate to early literacy instruction. Putting it another way, developmental research as reported in this and related works (e.g., McBride-Chang, 1999; Treiman, Kessler, & Bourassa, 2001; Treiman, Tincoff, & Richmond-Welty, 1996) will help to establish hypotheses that can then be directly tested in intervention studies that contrast approaches to teaching the alphabet. For instance, consistent empirical evidence showing that children learn letters of the alphabet contained in their own names relatively earlier than other letters might suggest that these letters ought not to be targeted extensively in early literacy instruction, as children will likely learn these letters implicitly and without direct instruction. Rather, instructional resources could be directed towards teaching those letters that tend *not* to be learned early or easily by most children.

### *1.2. Aims of the present study*

We conducted this research to test four hypotheses concerning the order by which young children learn the names of the individual alphabet letters. Two hypotheses, the own-name advantage and the letter-order hypothesis, relate to factors extrinsic to children as influential to their learning of individual letters. Extrinsic factors concern the social phenomenon of literacy learning, that is, that children acquire alphabet knowledge through their indirect and mediated influences with print at home and in school (e.g., Bennett, Weigel, & Martin, 2002). Support for extrinsic influences on children's learning of particular alphabet letters is provided indirectly by studies showing that children learn those letters earlier that are contained in their own names, as presumably children are exposed to the letters in their names more frequently than other letters (e.g., Bloodgood, 1999; McBride-Chang, 1999; Treiman & Broderick, 1998). Extrinsic factors also likely account for McBride-Chang's (1999) finding that kindergarteners know more letters occurring relatively early in the alphabet string compared to those occurring later, given that common instructional approaches often follow the order of the alphabet letters as a sequence for instruction.

Extrinsic factors fail to account, however, for the finding that children tend to learn some letters earlier than others as a function of the phonological structure of the names of letters themselves; for instance, children learn earlier those letters with names following a CV and VC phonological structure over those not following this pattern (McBride-Chang, 1999; Treiman, Tincoff, & Richmond-Welty, 1997). This phenomenon seems best explained by considering the intrinsic features of the letters themselves, particularly their phonological structure. Thus, the third and fourth hypotheses considered in the present research (viz., letter-name pronunciation effect, consonant-order hypothesis) examine factors intrinsic to the letters as possible influences to children's learning of them. A considerable literature suggests that intrinsic features of specific units of language, such as the phonological structure, lexical referent, or syntactic role of a given word, substantially influences the ease with which children learn those units (e.g., Storkel, 2001, 2003). Thus, it is not surprising that intrinsic features of individual alphabet letters also may influence children's learning. Here, we provide additional detail concerning the four hypotheses tested.

### *1.2.1. Own-name advantage*

The first hypothesis, called the own-name advantage (Treiman & Broderick, 1998), states that children learn earlier those alphabet letters that occur in their first name. This effect is currently the most well-established influence on children's learning of individual letters, and proposes that a major influence on children's alphabet learning is one that is idiosyncratic yet systematic (i.e., the letters learned first by individual children are dependent on the letters in their names). This effect is strongest for children's first initial of their first name and does not extend to children's last names (Treiman & Broderick, 1998). The effect has been shown for kindergarteners and first graders who are not only native English speakers (Treiman & Broderick, 1998) but also those who speak/read a variety of alphabetic languages (Hoorens & Todorova, 1988; Nuttin, 1985, 1987). The primary reason set forth for this finding is that of print exposure: children presumably see the letters of their own name more frequently in written form (e.g., posted on labels in their classrooms, penned to their pictures, etc.), providing an advantage to these letters.

### *1.2.2. Letter-order hypothesis*

The second hypothesis, called the letter-order hypothesis, states that children learn first those letters positioned earlier in the alphabet string relative to those positioned later in the string. McBride-Chang (1999) found a moderate correlation between children's knowledge of specific letters and their position in the alphabet string. These findings may reflect greater attention to the letters that occur at the start of the alphabet string during alphabet instruction, as some literacy programs use a "letter of the week" approach that follows the order of the alphabet string in instruction (McBride-Chang, 1999). Possibly, children also receive more exposure to the letters early in the alphabet string in informal learning contexts, including games and television programs (McBride-Chang, 1999). Like the own-name advantage hypothesis, the letter-order hypothesis rests primarily on the influence of children's exposure to the different letters, with heightened exposure (as might occur with letters early in the string) influencing the order of learning.

### *1.2.3. Letter-name pronunciation effect*

The third hypothesis, the letter-name pronunciation effect (or the structure hypothesis; Treiman et al., 1997), states that children learn earlier those letters of the alphabet containing their pronunciation in the name of the letter (McBride-Chang, 1999; Treiman & Broderick, 1998; Treiman et al., 1998). These letters (e.g., B, P, F) are more likely to be known by children compared to letters that do not have their name in their pronunciation (C, G, H, Q, W, Y), whereby the phonological composition of the letter names provides a "bootstrap" for learning. Among those letters containing their pronunciation within their names, Treiman and Broderick (1998) found an advantage for letters in which their pronunciation occurred in the onset of a consonant–vowel (CV) syllable (viz., B, D, J, K, P, T, V, Z) over those in which the name of the letter was in the vowel–consonant (VC) syllable's code (viz., F, L, M, N, R, S, X); however, this effect was not replicated in McBride-Chang's (1999) study, which found no difference between the two syllable structures. For the CV-pronunciation letters, these can be differentiated into those with a CV-/i/ syllable pattern (e.g., B, D, P, T, V, Z) and those with a CV-/eI/ pattern (e.g., J, K); Treiman et al. (1997) hypothesized an advantage for the CV-/i/ pattern over the CV-/eI/ pattern, but rejected this hypothesis in their study of children's acceptance of false-vowel patterns (e.g., /fi/ versus /feI) that showed no clear advantage for CV-/i/ letters. Nonetheless, the consistently observed advantage for CV and VC letters over those not following this pattern suggests that the phonological structure of letter names influences the ease with which children learn the names of individual letters. Unlike the own-name advantage hypothesis, the letter-name pronunciation effect is not idiosyncratic to the child, but rather relates to the invariant and intrinsic phonological characteristics of the pronunciation of individual letters.

#### *1.2.4. Consonant-order hypothesis*

The fourth hypothesis, the consonant-order hypothesis, states that children learn first those letters corresponding to earlier-acquired consonantal English phonemes relative to letters corresponding to later learned consonantal phonemes. This hypothesis presumes that children's developmental accomplishments in phonology may influence their alphabet learning, receiving some support from research showing that children's learning of individual letters is influenced by the phonological structure of their pronunciation. Although children tend to acquire vowel sounds early in their vocal development, with mastery in the first year, the acquisition of the consonantal phonemes occurs more gradually to transcend the end of the first year for early-acquired sounds (e.g., /m/, /b/) to the early elementary grades for later-acquired sounds (e.g., /l/, "th"). Children's acquisition of the consonants used in spoken language follows a fairly invariant developmental trajectory (e.g., Sander, 1972; Stoel-Gammon, 1987), and a variety of normative references provide the customary age at which children typically show mastery of specific consonantal productions in their speech (see Sander, 1972; Templin, 1957, for seminal work in this area). Articulatory features of the consonants, including the place and manner of articulation, influence the order of customary acquisition, in that some places (e.g., bilabial consonants, such as /m/) and manners (e.g., stop consonants, such as /b/ and /p/) of articulation are easier for the young child to produce and thus emerge earlier. We propose here that the more frequent articulation of earlier-acquired sounds (e.g., /m/, /b/, and /p/) may influence the robustness of their phonological representations given the integrative relationships between perceptual representations and motor-speech output in speech-sound production (Borden, Harris, & Raphael, 1994). In turn, the alphabet letters that correspond to more robust phonological representations may be learned more readily and earlier than sounds with which the child has had less experience and that are less well represented at the phonological or perceptual level.

To test the consonant-order hypothesis, which unlike the other three hypotheses has not yet been empirically studied, we differentiated the alphabet letters into six categories based on the time of acquisition of their consonantal counterparts based on data presented in Sander (1972). Those letters not having a single consonantal counterpart, including vowels, the semi-vowel Y, and the letters C, Q, and X, were not included in this analysis. Category I included letters B, H, M, N, P, and W, the consonantal phoneme counterparts of which are mastered by 50% of children by about 1.5 years of age. Category II included letters D, G, K, and T; their consonantal counterparts are mastered by 50% of children by about 2 years of age. Category III included letter F, for which the consonantal counterpart is mastered by 50% of children by about 2.5 years of age. Category IV included letters L, R, and S; their consonantal counterparts are mastered by 50% of children by about 3 years of age. Category V included letter Z; the consonantal counterpart is mastered by 50% of children by about 3.5 years of age. Category VI included letters J and V, for which the consonantal counterparts are mastered by 50% of children by about 4 years of age. Thus, the ordered categories represent differences in time of approximately 6 months.

### *1.3. Analytical approach*

The four hypotheses were tested using a cross-sectional design in which we identified the specific letters known by 339 low-income 4-year-olds at a single point in time. This sample was desirable for the present purposes, given that ample evidence shows that children at 4 years of age are developing their knowledge of the alphabet letters but are unlikely to have yet mastered the corpus of letters; this is particularly true for children from disadvantaged, lower-income households (Justice & Ezell, 2001; Lonigan et al., 1999). By focusing on this population specifically, we avoided the floor effects likely found for younger children and the ceiling effects typically found for older and/or more advantaged children. The majority of studies examining children's knowledge of individual letters have involved middle-class kindergarteners and first graders with fairly well-developed alphabet knowledge (e.g., McBride-Chang, 1999; Treiman & Broderick, 1998), which may have both obscured and confounded more nuanced understanding of influences on children's alphabet learning. Additionally, we drew our participants from preschool classrooms that were not utilizing curricula featuring specific approaches to alphabet instruction, thus potentially avoiding the confound of instructional experience. As McBride-Chang (1999) noted, her significant finding of an advantage for letters occurring earlier over those occurring later in the alphabet string may have been influenced by kindergarten policies in the classrooms she studied that required "the alphabet be taught beginning from the beginning" (p. 304).

To test the four hypotheses, we employed an explanatory item response theory model, namely the linear logistic test model (LLTM; Fischer, 1973; see Wilson & De Boeck, 2004). Under the LLTM, the item response is affected by a child-specific intercept (equivalently, trait level or alphabet knowledge) and item difficulty. Item difficulty is decomposed into a linear combination of item predictors, in this case variables reflecting own-name advantage, letter-order effect, letter-name pronunciation effect, and consonant-order effect. This model is equivalent to a multilevel logistic regression with letters nested within children. As with any logistic regression, the coefficients on the predictor variables can be converted to odds ratios that reflect the relative likelihood of a correct response given a one unit increase in the predictor.

## 2. Method

### *2.1. Participants*

The participants were 339 four-year-old children from 2 counties in Virginia attending 16 public preschool classrooms serving primarily at-risk children. The socio-demographic characteristics of the sites ranged considerably, with eight classrooms located in the southwestern rural and Appalachian region of the state, and the remaining located mid-centrally in an industrial and light-farming region. The 16 classrooms were enrolled in a large-scale study to test the effects of an experimental curriculum (Language-Focused Curriculum; Bunce, 1995) against the adopted curriculum (High/Scope; Hohmann & Weikart, 1995). Neither of these curricula advocates a specific sequence for teaching children the names of individual alphabet letters (see Table 1), although both explicitly identify alphabet learning as a curricular objective. Twelve of the 16 classrooms were enrolled in the larger study for 2 years, and for the present research we included data from 2 cohorts of children tested in the fall of 2003 and 2004. The 4 remaining classrooms participated in the larger study for only 1 year; children in these classes were tested in the fall of 2004. All of the children in the classrooms for whom informed parental consent was provided were tested for alphabet knowledge, often corresponding to 100% of pupils in a given classroom.

Seven of the classrooms were affiliated with Head Start, whereas the remainder was funded through Title I or the state's public pre-kindergarten (PreK) initiative, as shown in Table 2. These programs were designed primarily to serve at-risk children, and prioritized certain risk factors to determine eligibility. Admission in the Head Start classrooms was based on federal poverty guidelines to serve children residing in homes below federal poverty limits for the year 2003. Admission in the Title I classrooms was prioritized to serve children who scored 110 or lower on the *Speed Dial: Developmental Indicators for the Assessment of Learning* (Mardell-Czudnowski & Goldenberg, 1998). Admission to the state PreK program was prioritized for children and families exhibiting any one of several indicators of risk, to include household income, parental education, family stress, health or developmental concerns, or limited understanding of English.

At the time of initial assessment, the children (159 females and 180 males) ranged in age from 39 to 59 months, with a mean age of 54 months (S.D. = 3.6). In terms of ethnicity, 240 children were Caucasian, 65 were African American, 19 were Hispanic, 1 was Asian, 8 were designated as "other", and 2 were designated as mixed ethnicity (ethnicity information was unavailable for 4 children). All but 15 children were native English speakers and resided in homes in which English was the primary language spoken. Spanish was the primary language spoken in 14 of the other 15 homes, and an unspecified language was reported for the remaining households. All educational services were provided to these children in English. Standardized testing conducted 4 weeks into the academic year showed receptive vocabulary for 323 children to range from a standard score of 40 to 131, with a mean of 95.5 (S.D. = 13.5) based on the *Peabody*

Table 2
Participant sample ($n = 339$)

| Program | Gender | Ethnicity | Primary language | $n$ |
|---|---|---|---|---|
| Head Start | Female | African American | English | 22 |
| | | Caucasian | English | 27 |
| | | Hispanic | English | 1 |
| | | Hispanic | Spanish | 7 |
| | | Other | English | 2 |
| | Male | African American | English | 26 |
| | | Caucasian | English | 27 |
| | | Hispanic | English | 2 |
| | | Hispanic | Spanish | 5 |
| | | Other | English | 4 |
| State PreK | Female | African American | English | 10 |
| | | Caucasian | English | 8 |
| | | Mixed ethnicity | English | 1 |
| | Male | African American | English | 3 |
| | | Caucasian | English | 11 |
| | | Hispanic | Spanish | 1 |
| | | Asian | English | 1 |
| Title I | Female | African American | English | 3 |
| | | Caucasian | English | 74 |
| | | Hispanic | English | 1 |
| | | Not reported | English | 3 |
| | Male | African American | English | 1 |
| | | Caucasian | English | 93 |
| | | Hispanic | English | 1 |
| | | Hispanic | Spanish | 1 |
| | | Mixed ethnicity | English | 1 |
| | | Not reported | English | 1 |
| | | Other | English | 2 |

*Picture Vocabulary Test III* (Dunn & Dunn, 1997). Direct assessment of alphabet knowledge showed the mean number of upper-case alphabet letters known by participants to be 7.1 (S.D. = 7.5), with a range of 0–26 letters.

### 2.2. General procedures

Direct, standardized child assessments were conducted during a 4-week-assessment window that commenced approximately 4 weeks after the start of the academic year. A variety of measures were used to study children's language, literacy, social, and cognitive abilities. All measures were conducted by trained research assistants under the supervision of research personnel. Children were assessed in quiet locations outside of their classrooms in sessions approximately 30 min in duration.

For the present purposes, the assessment of relevance was examination of children's alphabet knowledge, evaluated using the Alphabet Knowledge subtest of the *Phonological Awareness Literacy Screening-PreK* (PALS-PreK) (Invernizzi, Sullivan, & Meier, 2001). For this subtest, children were presented with an 8 in. × 11 in. sheet of paper on which all 26 upper-case letters were presented in large bold print in a random order. To commence the subtest, the examiner gave the following instructions: *See these letters? Put your finger on each letter and name it. If you don't know the name of a letter, skip it and go on to the next letter.* The examiner identified children's responses for each letter on a recording sheet, and marked incorrect responses by drawing a slash through misidentified letters or unidentified letters, for a possible score range of 0–26. If a child self-corrected an answer before moving to the next item, the item was counted as a correct answer. During assessment, no praise, reinforcement, or corrective feedback was given with the exception of praise for on-task behavior as needed. Following testing, children were provided a small gift (e.g., stickers) and returned to their classrooms.

### 2.3. Data analysis

We employed the LLTM, or equivalently a multilevel logistic regression, with letters nested within children and a child-specific intercept to test the four hypotheses. The outcome of whether the child responded correctly for each of the 26 letters was predicted using a logistic regression by 7 predictors: (a) a dummy variable indicating whether the letter was contained in the child's most commonly used name (nickname or first name[1]), (b) a dummy variable indicating whether the letter was the initial letter of the child's most commonly used name, (c) the position of the letter in the alphabet (A = 1, B = 2C = 3, ...), (d) the age at which 50% of children can identify the phoneme associated with the letter (coded as missing for vowels, the semi-vowel Y, and for letters associated with more than one phoneme) based on data from Sander (1972), and (e) three dummy variables reflecting the consonant and vowel patterns contained within letter names, with the first comparing letters of a CV-/eI/ pattern to those of a CV-/i/ pattern, the second comparing letters of a VC pattern (VC) to those of a CV-/i/ pattern, and the third comparing letters following none of the above patterns (NOT) with letters of the CV-/i/ pattern. Vowels were coded as missing. The data were analyzed with the LLTM with a random person-specific intercept. The full model was:

$$\ln\left[\frac{\Pr(X_{ni}=1)}{\Pr(X_{ni}=0)}\right] = \theta_n + \beta_0 + \beta_1\, innick_{ni} + \beta_2\, f\ \ln ick_{ni} + \beta_3\, position_i + \beta_4\, ph\_age_i + \beta_5 d_i^{12} + \beta_6 d_i^{13} + \beta_7 d_i^{14}$$

where $X_{ni}$ is the response to letter $i$ by child $n$ (1 = correct, 0 = incorrect); $\theta_n$ is a normally-distributed person-specific intercept with mean 0; $innickn_i$ is a dummy variable equal to 1 if the letter $i$ is in the nickname/first name of child $n$; $flnick_{ni}$ is a dummy variable equal to 1 if letter $i$ is the first letter of the nickname/first name of child $n$; $position_i$ is the position in the alphabet of letter $i$; $ph\_age_i$ is the age of phoneme acquisition of letter $i$; and the $d_i$s are dummy variable indicating the CV pattern of letter $i$. In terms of multilevel modeling, there were two levels: letter responses (level 1) nested within children (level 2), with the intercept, the only level 2 random effect, having no predictors. For letters with missing predictors (multiple phonemes for ph_age and vowels for CV pattern), we employed multiple imputation with 10 imputations using SAS PROC MI. The model was estimated using PROC NLMIXED for each of the 10 imputed data sets; results were combined using PROC MIANALYZE. The script is available by request.

## 3. Results

The percentage of children knowing each of the 26 alphabet letters is presented in Table 3. As shown, the letters B, X, O, and A were known by the greatest percentages of children, whereas V, U, N, and G were known by the fewest. For the most commonly known letters, 55%, 48%, 44%, and 44% of children, respectively, for B, X, O, and A, knew these letters. For the least commonly known letters, 13%, 15%, 16%, and 17% of children, respectively, for V, U, N, and G, knew these letters.

Results from the LLTM are summarized in Table 4. The first hypothesis considered was the own-name advantage. Descriptive statistics supported this hypothesis: letters in the first or nickname were known with a higher rate (37% of children) than letters not in the child's first or nickname (25% of children). The first letter of the child's first or nickname was especially well known (59% of children). Results of the LLTM showed that letters in children's first names were 1.5 times as likely to be known as letters not in their first names. The child's first initial was an additional 7.3 times as likely to be known, for a total effect of 7.3 × 1.5 = 11.0. That is, the first letter of the child's name was 11 times more likely to be known than a letter not in that child's first name.

The second hypothesis considered was the letter order hypothesis. On average, letters in the first half of the alphabet string had a slightly higher percentage correct (29%) than letters in the second half (26%), an effect supported by the LLTM. Children were 1.02 times more likely to know a letter one position earlier in the alphabet (e.g., A was 1.02 times more likely to be known than B, controlling for all other effects), supporting a small but reliable order effect with A 1.5 times more likely to be known than Z (as calculated by taking 1.02 to the 25th power).

[1] We identified children's most commonly used names through a teacher questionnaire that asked teachers to identify the names children go by in the classroom.

Table 3
Alphabet letters known by children

| Alphabet letter | Percentage of children |
|---|---|
| A | 44 |
| B | 55 |
| C | 30 |
| D | 31 |
| E | 24 |
| F | 20 |
| G | 17 |
| H | 24 |
| I | 21 |
| J | 27 |
| K | 34 |
| L | 24 |
| M | 28 |
| N | 16 |
| O | 44 |
| P | 22 |
| Q | 21 |
| R | 22 |
| S | 35 |
| T | 27 |
| U | 15 |
| V | 13 |
| W | 22 |
| X | 48 |
| Y | 25 |
| Z | 23 |

The third hypothesis we considered was that the syllable structure of the letter's name would affect when a child learned the letter. The percentage of letters known by children differed only somewhat across different syllable structure patterns: CV-/i/, 29%; CV-/eI/, 31%; VC, 28%; and NOT, 23%. The LLTM showed one significant difference after controlling for the effects of the other variables in the item prediction. Children were 1.8 times more likely to know a CV-/i/ than a NOT letter. However, children were no more likely to know a CV-/eI/ or VC letter compared to a CV-/i/ letter.

Finally, the fourth hypothesis we tested was the consonant-order hypothesis. As noted earlier, letters were differentiated into six categories based on the age of phoneme acquisition, with Category I representing the earliest acquired consonantal counterparts and Category VI representing the latest acquired consonantal counterparts. Percentage correct generally decreased over the six categories: I, 28%; II, 27%; III, 23%; IV, 27%; V, 23%, VI, 20%. The LLTM analysis supported the consonant-order hypothesis; for each earlier category of acquisition that a consonantal phoneme

Table 4
Results from LLTM

| Hypothesis | Variable | Effect | 95% Confidence interval |
|---|---|---|---|
| 1 | Letter is in name | 1.5 | [1.25, 1.76] |
| 1 | Letter is initial of name | 7.3 | [5.2, 10.2] |
| 2 | Position in alphabet (for each position earlier in alphabet) | 1.02 | [1.01, 1.03] |
| 3 | CV-/i/ vs. CV-/eI/ | n.s. | [0.9, 1.5] |
| 3 | CV-/i/ vs. VC | n.s. | [0.6, 1.1] |
| 3 | CV-/i/ vs. NOT | 1.8 | [1.5, 2.2] |
| 4 | Age of phoneme acquisition (for each 6 months earlier) | 1.09 | [1.04, 1.15] |

*Note*: Effect is the odds ratio of responding correctly to a letter for each unit change in the variable. Effects marked as n.s. are not significantly different from 1 (i.e., no effect).

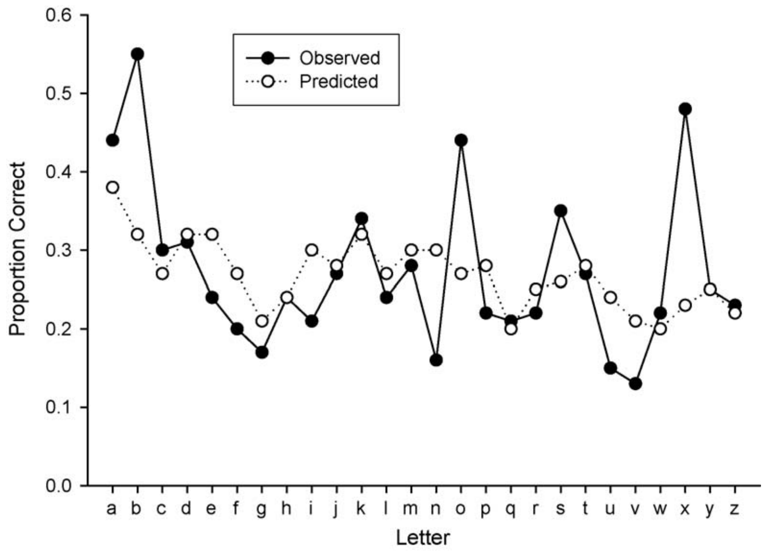


Fig. 1. Graphic depiction of observed and predicted percentages of children knowing the individual alphabet letters.

was acquired, children were 1.09 times more likely to know the associated letter compared to the next category (e.g., Category I versus Category II, or approximately 6 months later acquisition).

As a final analysis, we examined the precision of our model for estimating the probability of correct responses for each letter. We calculated the expected proportion of correct answers for each letter based on our analyses and compared them to the observed proportions. Results are presented in Fig. 1. In general, the predicted values are close to the observed proportion correct. The most pronounced exceptions are B, O, and X, corresponding to the letters known by the most children. The high residual may be due to regression to the mean, but may also reflect something idiosyncratic about these letters that should be explored further in future research.

## 4. Discussion

Current educational policies and practices emphasize the importance of ensuring that all children enter school ready to learn. One readiness skill consistently emphasized in policy documents is that of alphabet knowledge (e.g., Administration for Children and Families, 2002). This emphasis stems from empirical findings showing a robust and reliable relationship between early alphabet knowledge and later word recognition abilities (e.g., Hammill, 2004; Lonigan, 2004); the considerable prediction power of alphabet knowledge for identifying children at-risk for later reading difficulties (e.g., Catts et al., 2002; Gallagher et al., 2000); and reports that a significant number of children (particularly those from lower-income homes) enter school with relatively under-developed knowledge of the alphabet (e.g., Invernizzi, Justice, Landrum, & Booker, 2004). In light of such evidence, there is a need for both applied research that investigates the effectiveness of various approaches to building early alphabet knowledge (e.g., Justice & Ezell, 2002) as well as developmental research that improves our understanding of children's learning in this area.

A growing body of research shows that a variety of extrinsic factors influence children's learning of the alphabet as a whole and of the letters as individual units. For instance, children who participate frequently in adult–child shared storybook reading that includes a deliberate focus on print have better alphabet knowledge relative to those for whom such experiences are infrequent (e.g., Bennett et al., 2002; Justice & Ezell, 2000). Children's tendency to learn those letters earlier that are contained in their own names (particularly their first initial) also suggests that exposure to letters is a primary vehicle for learning the individual letters (e.g., Treiman & Broderick, 1998).

Research also suggests that some intrinsic factors specific to the individual letters themselves also influence children's alphabet development. Treiman et al.'s (1997) "structure hypothesis" emphasizes the importance of studying the features of letters themselves for improving our understanding of how children learn letter names: they contend that children employ their phonological knowledge in learning the names of individual letters. Studies by Treiman and Broderick (1998) and McBride-Chang (1999) have shown that letters containing their pronunciation in their names (e.g., B, L,

M) are known by more kindergarteners and first graders than other letters. Developmental research that tests these and other hypotheses concerning children's learning of individual letters will be informative to intervention studies that examine various approaches to facilitating early alphabet development, including the selection and ordering of letters as instructional targets. The current variability in approaches to alphabet instruction suggests that current best practices primarily draw from craft-based precedence rather than empirically-validated methods. Although the present work was not conducted to test a specific approach to alphabet-knowledge instruction, insights gained from the present work and related studies can provide important guidance to future applied studies, of which there is a need.

In the present research, four hypotheses were tested to provide explanatory information concerning the order by which preschool children learn the names of the individual letters of the alphabet. We briefly consider our findings here for each hypothesis tested. First, the own-name advantage hypothesis states that children are more likely to know letters that occur in their own names (see McBride-Chang, 1999; Treiman & Broderick, 1998), with a particular advantage for one's first initial. Our research confirmed this hypothesis, with multilevel logistic regression permitting us to specify the extent of this advantage. Specifically, children were 1.5 times more likely to know the letters in their own first names, and 7.3 times more likely to know their first initials. Presumably, this effect relates to the frequency with which children are exposed to their names in written form: as Treiman and Broderick (1998) note, throughout the years of early schooling, "children's coat hooks, cubbyholes, and drinking glasses are often labeled with the children's names" (p. 98).

An additional possibility for the own-name advantage concerns children's motivation, in that children may be more interested in the letters appearing in their own names given their sense of "ownership." Developmental researchers have long suggested that ownership of an object is a sufficient condition to render that object more salient than other similar "non-owned" objects (e.g., Nuttin, 1987), and it is plausible that ownership is as influential as mere exposure in explaining the own-name advantage. Regardless of the mechanism, confirmation of this hypothesis suggests (albeit indirectly) that the influence of children's environmental exposures to letters in print, during incidental and more direct encounters, is an important mechanism for children's learning of the individual letters. Importantly, this finding also shows that the order of letter learning is highly variable among children, in that the letters learned earliest by a particular child are influenced by the letters contained (or not contained) in his/her own name.

Second, the letter-order hypothesis states that children are more likely to know letters that occur earlier in the alphabet string (e.g., A, B, C) relative to those occurring later in the string (e.g., X, Y, Z). In the only study we identified examining this effect, McBride-Chang (1999) found a moderate correlation between kindergarteners' knowledge of letter names and their order in the alphabet string. McBride-Chang appreciated, however, that this effect may have been confounded by the literacy instruction in the classrooms of her participants, which sequenced instruction to follow the order of the letters. The present research drew children from classrooms following no prescribed sequence of alphabet instruction in an attempt to avoid this confound. Results provided modest support for the letter-order hypothesis, finding that children were 1.02 times more likely to know a letter one position earlier in the alphabet; thus, L would have an advantage over M, M would have an advantage over N, and so forth, with A 1.5 times more likely to be known than Z. This effect thus implies a slight advantage for letters occurring earlier in the alphabet string, possibly due to the salience afforded to earlier letters in songs and games or using the ordered alphabet string as a prevalent approach to organizing instruction.

Third, the letter-name pronunciation effect states that children are more likely to know letters for which their pronunciation contains the sound of the letter versus those that do not (e.g., B versus W), with the former category of letter including three possible syllable structures: CV-/i/ (e.g., B, D), CV-/eI/ (e.g., K, J), and VC (e.g., F, L). Although theoretical perspectives have suggested an advantage of CV-/i/ over CV-/eI/, this effect has not yet been empirically proven (Treiman et al., 1997); likewise, although studies have consistently shown an advantage of CV and VC over NOT words (McBride-Chang, 1999; Treiman & Broderick, 1998), the advantage of CV over VC letters reported by Treiman and Broderick (1998) was not replicated by McBride-Chang (1999). The present findings converged in part with previous studies showing a letter-name pronunciation effect, finding children to be 1.8 times more likely to know CV-/i/ letters compared to NOT letters; yet, we observed no reliable differences in letter-name knowledge among CV-/i/, CV-/eI/, and VC letters. Our findings show that the phonological structure of the names of letters, at least in part, provides a bootstrap to children's learning of those letters, but only for those with a CV-/i/ syllable structure compared to letters not containing their names in their pronunciations. Nonetheless, our finding of no appreciable differences among those letters containing their own names in them (whether CV or VC) suggests no advantages among these letters as a function of phonological structure.

Fourth, the consonant-order hypothesis proposes an advantage for letters corresponding to consonantal phonemes mastered earlier in development over those mastered later (the consonant-order hypothesis). This hypothesis received support in our finding that children were about 1.09 times more likely to know letters corresponding to consonantal phonemes developed in the immediate preceding category of mastery, so that letters B, H, M, N, P, and W would have an advantage over letters D, G, K, and T. Although an apparent modest effect, this effect was only slightly less than that seen for the letters in children's own first names (aside from the first initial). Like the letter-name pronunciation effect, the advantage for letters that correspond to earlier-acquired consonantal phonemes likely relates to the phonological system of the developing child. Given the strong interrelationships among phonological development (to include both internal phonological representations as well as phonological production) and children's early literacy learning (to include alphabet knowledge), we were not surprised to find additional confirmation that phonological developments influence the order of children's learning the names of various letters. We propose that the more frequent production of earlier-acquired sounds influences the robustness of their internal phonological representations; in turn, those letters corresponding to more robust representations are more readily learned relative to those letters corresponding to sounds learned later.

As a summary, the present research suggests that both extrinsic and intrinsic factors influence children's learning of the individual letters, to include both familiarity with the individual letters achieved through environmental exposure as well as the phonological features of the letters themselves. The single largest advantage was seen for children's first initials (improving the likelihood of knowledge of a letter by about seven-fold), contrasted with an approximately one and a half- to two-fold advantage for the other letters in children's first names, letters occurring earlier in the alphabet string, letters of a CV-/i/ pattern over NOT letters, and letters corresponding to earlier-acquired consonantal phonemes. An important implication of this work, and one that confirms previous studies, is that the order of letter learning is highly variable among children, given that letters in children's own names are privileged over other letters in order of acquisition. Additionally, our research, converging with that of previous reports, shows that there are differences, albeit generally modest ones, among the individual alphabet letters in the order with which children learn them that also stem from the intrinsic features of letters themselves, such as how they are pronounced and their placement in the alphabet string.

### *4.1. Limitations*

Several limitations to the present work warrant consideration. The first limitation concerns our method of alphabet assessment; this study examined children's knowledge of the upper-case letters using a single naming task. The order of the letters on our alphabet task was not randomized across children; rather, each child was presented the letters in the same order. It is not clear that similar findings would be observed for lower-case letters, for alternative approaches to alphabet knowledge assessment that involve reception rather than expression (e.g., pointing to a named letter from an array), or for different ordering of the alphabetic stimuli. An interesting line of research that, to our knowledge has not yet been pursued, is considering whether children's knowledge of the upper-case letters influences their learning of lower-case letters. McBride-Chang (1999) found that knowledge of letter sounds was contingent upon knowledge of individual letter names, so it possible that knowledge of an upper-case letter influences a child's knowledge of its lower-case counterpart, adding an additional source of variability in children's learning of the individual letters. Thus, confirmation of our findings with alternative approaches to alphabet assessment, including use of lower-case letters, is needed.

A second limitation is that we likely failed to account for additional influences on children's knowledge of the individual letters. For instance, we did not include a hypothesis concerning the potential impact of letter frequency on children's order of letter learning. The letters known by most children in our study included B, O, and X, and our analyses failed to predict these high rates of observed responses, and perhaps children know these letters because they frequently see them in print. McBride-Chang (1999) also found that relatively high numbers of children knew B (68% of sample) and X (48% of sample), but relatively fewer children knew O (37% of sample). It may be that children learn O and X through games (tic-tac-toe) and exposure to road signs (e.g., STOP signs, railroad crossing signs), although the effect for B is less clear. A more nuanced investigation that accounts for the frequency with which children are exposed to specific letters at home, in the classroom, and in the community is needed to rectify these findings.

A third limitation warranting mention involves our sample and, consequently, the generalizability of our findings. Our participants were drawn from a single state and from a relatively small number of classrooms. Additionally, these children had been identified as at-risk, primarily based on socioeconomic status. While this sample is desirable for several reasons, including the avoidance of ceiling effects in alphabet measurement, the extent to which our findings would be replicated in more diverse samples (e.g., middle-class children, children from other geographic locations) is unknown. Likewise, our sample included several children for whom English was not their native language, although they were attending English-instruction programs. The extent to which a child's native language may influence the order of letter learning was not studied, thus we cannot conclude that the results are generalizable to children whose native language is not English.

Additional limitations include our analytical approach. To test the letter-name pronunciation effect and the consonant-order hypotheses, there was a substantial amount of missing data in that these hypotheses only addressed certain letters. We adjusted for this using multiple imputations. However, the results for these two predictors cannot be considered as strong as those hypotheses tested without missing data. Also, interpreting item difficulty as reflecting order of learning can be problematic. In this study we used cross-sectional data to make longitudinal interpretations, and we advise some caution in this interpretation (Molenaar, Huizenga, & Nesselroade, 2003). Future research that uses longitudinal data to document the order of children's alphabet learning is a possible next step in this line of research. Nonetheless, it is important to note that longitudinal data may suffer from important practice effects (Ferrer, Salthouse, Stewart, & Schwartz, 2004; Salthouse, Schroeder, & Ferrer, 2004), particularly for alphabet learning given the constrained nature of the letter stimuli (i.e., there are only 26 units). It is possible that a longitudinal design presents no significant advantage over the cross-sectional design, but this is a methodological question of distinct interest to developmental researchers and one that warrants careful scrutiny. In short, given the need to improve our knowledge of how children go about learning the names of individual letters (and how educators might better support this learning), these limitations provide guidance to future studies that seek to further our understanding of this complex and important developmental phenomenon.

### *4.2. Future directions in educational policy and practice*

Although this study did not investigate the impact of specific approaches to alphabet instruction, its findings may be informative to future efforts to improve educational policy and practice as they relate to early literacy instruction. Currently, we have relatively little theory and data available to guide alphabet instruction in preschool programs, particularly as compared to other aspects of language and literacy development (e.g., vocabulary, phonological awareness, print awareness). Thus, current instructional approaches to alphabet instruction lack a strong evidence base, implicating the need for rigorous programmatic research that evaluates the impacts of competing approaches.

In consideration of the present findings as well as those in previous reports, it is clear that some letters are learned earlier by children compared to other letters. We see relatively strong effects for the letters contained in children's own names (particularly the first initial), and more modest yet consistent effects for the order of the alphabet string, the phonological structure of letter names, and the order of consonantal phoneme acquisition. Although such differences exist among the letters, it is reasonable to ask how awareness of these differences might influence educational practices. The literature on interventions to promote children's phonological development provides an example of how basic research on the emergence of developmental phenomena can guide experimental studies that identify the most effective and efficient approaches to bring about developmental change, particularly with respect to selecting targets for instruction.

Historically, phonological interventions followed a developmental sequence of speech-sound acquisition that taught one sound at a time (typically to mastery), starting with earlier-acquired sounds and moving to later-acquired sounds. Speech therapists used descriptive data concerning the typical order of emergence for speech sounds, such as Sander's (1972) data we drew from in the present work, to order speech-sound targets during intervention. In the 1990s, researchers began to compare various approaches to target selection, such as the outcomes of phonological intervention when targeting earlier-acquired sounds versus later-acquired sounds. These studies fostered an important paradigm shift in the field of phonological intervention by showing that targeting later-acquired sounds rather than earlier-acquired sounds resulted in more robust phonological outcomes and greater change in the child's developing phonological system (e.g., Gierut, Morrisette, Hughes, & Rowland, 1996).

By comparison, consider how the present work (and the related corpus of studies) might be used to guide future intervention research focused on identifying the most effective and efficient approaches to alphabet instruction. First, recognition that substantial numbers of children arrive to kindergarten with relatively little knowledge of the alphabet indicates that current instructional approaches are not as rigorous as they ought to be, particularly for our most at-risk learners. Second, as we build an applied research base that improves efforts in this area, this research ought to be informed by developmental findings that establish specific hypotheses to be tested. The present findings suggest that beyond simply evaluating the outcomes emerging from various instructional approaches (e.g., incidental approaches versus explicit approaches), we also ought to consider whether outcomes vary for different target-selection approaches. For instance, if evidence points to some letters as being learned relatively early by many children, perhaps letter instruction should target letters that hold no such advantage.

Following from the hypotheses studied in this research, it is plausible to ask whether children might develop their alphabet knowledge more rapidly within preschool programs if educators would explicitly target those letters that tend to be acquired later rather than those typically acquired early. Specifically, instruction might start with letters occurring later in the alphabet string (e.g., V, W, X, Y, Z), letters for which their pronunciation is not contained in their names (e.g., C, G, H, Q, W, Y), and letters corresponding to later-acquired phonemes (e.g., J, L, R, S, Z). This approach to instruction could be contrasted with approaches that emphasize teaching letters following alternative orders, including following the alphabet string or focusing on letters of high frequency or of personal significance to children (e.g., letters in own name and those of family members). Longitudinal studies can provide evidence concerning whether any one target-selection approach is better than other approaches for supporting children's later reading development.

An additional possibility stemming from our findings is that early literacy instruction ought to use multiple approaches to build children's alphabet knowledge, given that there appears to be great variability among children in the specific letters they know. The children in our sample, comprising primarily those from lower-income homes, knew an average of seven letters in the fall of the academic year, and the specific letters known by individual children was highly variable. It is not clear that the approaches used in alphabet instruction adequately appreciate these individual differences. For instance, use of a letter-a-week approach represents a uniform strategy in which all children learn the same letter each week, often following the order of the alphabet string (see Table 1). Presuming that A would be taught in the first few weeks of school, it stands to reason that many children whose first initial is A (Allison, Alexander, Andrew, etc.) will already know this letter, whereas some children may have never seen this letter before. Thus, educators may wish to combine a variety of approaches to ensure that their methods of instruction meet the needs of all pupils and allow for appropriate differentiation to reflect the variability by which children learn the individual letters.

The results of this paper suggest the importance of ongoing basic and applied research on children's development of alphabet knowledge for moving the field of practice to the level of nuance implied here. As the results show, children's learning of the individual letters is influenced by a variety of factors, all of which ought to be considered in early literacy instruction. Consistent with current shifts in educational policy emphasizing the importance of scientifically-based practices, practitioners require access to instructional approaches that bring about the greatest developmental change in children's alphabet knowledge in the shortest period of time, given that children require relatively sophisticated alphabet knowledge for seamless transition to the rigors of kindergarten reading instruction.

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