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Preschoolers' Alphabet Learning: Cognitive, Teaching Sequence, and English Proficiency Influences

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ABSTRACT

In the study, the authors addressed two areas of inquiry: the influence of enlisting three underlying cognitive learning processes in alphabet learning, and order effects for letter name and letter sound instruction. Alphabet instruction was designed to enlist paired-associate learning (PAL) only, PAL plus orthographic learning, or PAL plus articulatory learning. Subjects were 94 preschool children, including 35 dual-language learners, in eight public preschool classrooms with low-income eligibility thresholds. Children were randomly assigned within each classroom to small groups that were randomly assigned to one of the three treatments and to one of two orders in which letter names and letter sounds were taught. Research assistants provided 10 weeks of instruction for 12–15 minutes per day, four days a week. All children in the three treatments made significant growth from pretest to posttest on all measures of alphabet learning. Children in the PAL-only condition had significantly higher gains than the sample average on four of the five alphabet measures. Post hoc tests showed that PAL only significantly outperformed the other two conditions on four of the five measures but only for native English-speaking children. No evidence of differences among treatments was found for dual-language learners. Additionally, there was no main effect for order of letter name or letter sound instruction, although teaching letter sounds before letter names was statistically significantly better in the PAL-only treatment. Findings support explicit alphabet instruction emphasizing the relation between verbal letter labels and letter forms that enlists PAL processes.

Acquisition of English alphabet knowledge requires children to learn initially 26 letter names and their most typical associated letter sounds in both uppercase and lowercase letter forms, a large number of associations. In spite of its apparent simplicity, learning these arbitrary correspondences between letter forms and their names or sounds presents a challenge for many young children. This challenge may be acutely daunting for children whose early literacy experiences include less English print exposure and English speech sound exposure. Reading is so recent a cultural invention that learning to recognize print has required modification of brain anatomy (Dehaene, Cohen, Sigman, & Vinckier, 2005). Brain studies have revealed that an extended time of up to four years is required for automatic and integrated letter–sound processing (Froyen, Bonte, van Atteveldt, & Blomert, 2009). In this article, we use the term *alphabet knowledge* to refer to children's competence in accurately and quickly identifying printed letter names and letter sounds.

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The importance of high levels of alphabet knowledge has been underscored by two findings: Letter name knowledge is a powerful predictor of both learning to read and later reading achievement, including comprehension (Foulin, 2005; National Research Council, 1998). The challenge of learning the alphabet has been verified by evaluations of the Early Reading First initiative, which found modest levels of alphabet learning by the end of one year of preschool attendance (Jackson et al., 2007), a troubling rate of progress for those children who enter preschool with the lowest levels of English alphabet knowledge. (Throughout this article, the term *preschool* conforms to the conventional usage of referring to programs serving children ages 3–5 prior to kindergarten entry.) Failure or delay in acquisition of alphabet knowledge predicts risk for reading difficulties (e.g., National Research Council, 1998; O'Connor & Jenkins, 1999; Snowling, Gallagher, & Frith, 2003). There is stability in the predictive utility of preschool predictors for later reading (Stanovich, 1986), and a strong preschool literacy foundation is protective against reading difficulty (see Duncan et al., 2007). The influence of alphabet knowledge in children's journey to becoming literate and the learning challenges that it presents for many underscore the importance of developing effective alphabet instruction.

Yet, the National Early Literacy Panel (2008) reviewed just three studies of alphabet instruction only (not combined with other instructional components) meeting inclusion criteria. The most recent meta-analysis of alphabet instruction concluded that it was not possible to extract meaningful information on the features of alphabet instruction leading to learning because there had been too few studies detailing the instruction (Piasta & Wagner, 2010a). Previous studies have not disaggregated the findings for dual-language learners (DLLs). (The term *dual-language learner* in this article refers to children who are learning English as a second language based on parent report, teacher confirmation, and a test of overall English proficiency. It is largely synonymous with the terms *English learner*, *English language learner*, and *emergent bilingual*.) Our review of these studies and a limited number of others published since this meta-analysis (e.g., Cardoso-Martins, Mesquita, & Ehri, 2011; McGinty, Breit-Smith, Fan, Justice, & Kaderavek, 2011) revealed that few studies set forth a principled model of instruction that took into account how children learn letters. In addition, we found no studies that systematically compared the order of teaching letter names or letter sounds in spite of the theoretical interest in the possibility that letter name knowledge may pave the way for learning letter sounds.

Heeding the call for research to examine more closely the elements of effective alphabet instruction and our analysis of the instructional design of existing studies, we identified three cognitive learning processes (CLPs) that are central to alphabet learning and design instruction to draw on and activate them to differing extents. We use the term *cognitive learning processes* to refer to a suite of three internal thinking processes central to alphabet learning: paired-associate learning (PAL), articulatory learning (AL), and orthographic learning (OL). Using a randomized control trial, we tested the effect on alphabet learning of adding more of each CLP to an instructional baseline of PAL, which is obligatory in alphabet learning. In addition, we tested the conceptual idea that letter name instruction may bootstrap the effectiveness of letter sound instruction by varying the order in which letter names and letter sounds were taught.

Relations Among Alphabet Knowledge, Phonemic Awareness, Reading, and Spelling

Alphabet knowledge is necessary for word reading. One reason for this is that letter sound knowledge, along with phonemic awareness (Byrne & Fielding-Barnsley, 1989, 1990), is necessary to acquire the alphabetic principle, the insight that print systematically maps speech. Children's informal encounters with letters and printed words, as well as experience with high-quality explicit instruction, lead to the understanding that the relation is systematic (de Graaff, Bosman, Hasselman, & Verhoeven, 2009). Acquisition of the alphabetic principle supports a rudimentary understanding of decoding. When children have a deep understanding of the details of the alphabetic principle in the form of extensive knowledge for how printed letters in words map onto the sounds in spoken words, it benefits learning to read words accurately and automatically and forming strong memories between word pronunciations and spellings (Ehri, 2005; Fielding-Barnsley, 1997).

Knowledge of letter names and letter forms also leads children into the initial stage of spelling. Children use their emerging knowledge of letter names and letter writing in their invented spelling. For example, children may use their knowledge of the initial sound in the letter *B* and the letter name *L* to spell the word *bell* as *BL*. This phonological spelling made possible by children's knowledge of letter names and letter sounds is a first step in learning conventional spelling skills (Treiman, 1994).

Many studies have indicated that preschoolers' alphabet knowledge (most often letter names) and phonological awareness are closely related and bidirectional in influence (Burgess & Lonigan, 1998; Foulin, 2005; McBride-Chang, 1999; Share, 2004), although others have not (de Jong, 2007; Treiman, Pennington, Shriberg, &

Boada, 2008). Both competencies independently contribute to learning to read, spell, and write (Ehri, 2014). Finally, preschool competence in both alphabet knowledge and phonological awareness predicts subsequent reading acquisition (Lonigan, Burgess, & Anthony, 2000). Predictive and causal relations among phonological awareness, decoding, and word recognition have been well established (for a review, see Ehri et al., 2001).

CLPs

Three CLPs central to alphabet learning are PAL, AL, and OL. These processes differ in the degree to which they are specific to literacy. PAL is a fundamental process of human cognitive architecture and is robustly involved in many types of learning. AL is language-specific and involves movements of the speech apparatus. OL is specific to literacy and refers to learning the written symbols used to represent speech sounds. Individual letters, multiletter spelling patterns, and spellings for whole words are components of orthography. We label them as processes to highlight our interest in and focus on their dynamic engagement during instruction.

PAL

Learning to read involves associative learning: associating the names and sounds that systematically correspond to the written letters and securing those connections into long-term memory (Ehri, 2005; McBride-Chang, 1999). Other examples of associative learning are pairing spoken words or labels with printed pictures or symbols. PAL is activated and exhibited when children pair the printed letters of the alphabet with their names and sounds and form memories of the pairing. Thus, in alphabet learning, PAL links orthographic information and speech (Adams, 1990; Bond & Dykstra, 1967; Muter, Hulme, Snowling, & Taylor, 1998). Individual differences in PAL are related to reading acquisition and ability (Hulme, Goetz, Gooch, Adams, & Snowling, 2007; Kalashnikova & Burnham, 2016; Litt, de Jong, van Bergen, & Nation, 2013; Litt & Nation, 2014; Warmington & Hulme, 2012; Windfuhr & Snowling, 2001). Children typically are first tasked with learning the 26 letter names and 26 letter sounds (short vowels and the most common consonant sounds) of the printed letters of the alphabet. Learning this large number of initial associations is very challenging for novices (Kilpatrick, 2015; Seidenberg, 2013). Mastery of letter name knowledge is present in only 70% of kindergarten children after a year's instruction by teachers receiving extensive professional development (Paige, Rupley, Smith, Olinger, & Leslie, 2018). Alphabetic knowledge sufficient to benefit early word reading is demonstrated when children produce the correct verbal label in response to presentation of the letter form. This task is commonly called letter identification.

Various problems may arise. Children may struggle with learning to recognize the letter forms, learning the individual names or sounds that go with the letter forms, or making the association between the letter forms and the labels (Hulme et al., 2007). The challenges inherent in learning to associate letter names and letter sounds with printed letters is further complicated because English has more phonemes than graphemes, and children must eventually learn how approximately 44 English phonemes map on to single letters and multiletter strings. The well-established relation of PAL and reading outcomes warrants study of alphabet instruction that explicitly supports forming rudimentary connections between speech and written letters. In the first treatment in this study, more PAL was included in alphabet instruction by explicit and contiguous presentation of letter forms and their verbal labels, and opportunities for children to produce pairings between written letters and verbal labels during all instructional routines.

AL (PAL+AL)

The alphabet represents letter sounds or phonemes that are produced by articulatory gestures, the rudimentary elements of language, and awareness of these gestures supports phoneme perception (Brown, 1978; Liberman, 1999; Liberman & Mattingly, 1985). These motor patterns are imbedded and interleaved in speech, and brain studies have indicated that articulatory movements contribute to phoneme perception (D'Ausilio et al., 2009; van Atteveldt, Formisano, Goebel, & Blomert, 2004). Measures of speech production accuracy index phonological representations in preschool children (Anthony et al., 2011). Children from low-income families and English learners with limited English-language exposure may have difficulty in perceiving these English phonemes with the precision and accuracy needed to represent distinct English letter sounds (Mauer & Kamhi, 1996). In a study of kindergarten DLLs, Roberts (2005) found that English articulation accuracy was significantly and as strongly associated with kindergarten phonemic awareness and with first-grade nonword reading as was letter sound knowledge.

Training studies have featured strategies to draw children's attention to articulatory gestures. Interventions with older children to learn the categories of mouth shapes and gestures associated with English letter sounds, including practice to improve articulation quality, have reported benefits for word and nonword reading (Ehri, 2014; Torgesen et al., 1999; Wise, Ring, &

Olson, 1999). The benefits of articulation training with preschool-age children have also been reported (Boyer & Ehri, 2011). In the second treatment in this study, we examined alphabet instruction comprised of basic PAL routines plus routines to reference articulation of letter names and sounds in order to draw children's attention to articulatory gestures and thereby sharpen their phoneme representations and strengthen memory and retrieval of the verbal label component of pairing of verbal labels and written letters. We designed activities to increase children's awareness of mouth gestures via pictures of mouth movements, exploration of mouth movements with mirrors, and feeling the speech apparatus as letter names and letter sounds were articulated.

OL (PAL+OL)

In OL, children learn to attach verbal labels (names or sounds) to the visual alphabet symbols, the printed letters (Hulme, 1981). The ability to process orthographic information required for reading is dependent on reshaping innate basic perceptual abilities to include an orthographic-specific visuoperceptual processing ability (Dehaene, 2009; Dehaene et al., 2010). This reshaping is accompanied by growing proficiency that occurs from encountering and learning about print.

Most research on OL, conducted with children who can read words, has utilized tasks involving whole words. There has been limited study of OL in young children or nonreaders (Castles & Nation, 2008) and of learning the basic orthographic symbols (individual letters). As children apply their alphabet knowledge to decode words, they slowly build orthographic knowledge of whole words and letter sequences (see Share, 1995). This process is called self-teaching.

At an early stage of literacy, OL reflects children's ability to learn the forms of printed letters that represent sounds and to store and retrieve these letters or clusters of letters. Children's ability to visualize the printed letters may provide a memory aid for retrieving abstract and acoustically fleeting letter names and sounds (Castles, Wilson, & Coltheart, 2011). Preschoolers' (Apel, Wolter, & Masterson, 2006) and kindergartners' (Apel, 2009; Wolter & Apel, 2010) knowledge of these representations uniquely contributes to early reading and spelling.

Early literacy experiences that develop English orthographic knowledge, such as English parent–child book-reading interactions and English letter-writing activities, may have occurred less frequently for DLLs and children from lower income families (Levin & Aram, 2005; Mol & Bus, 2011) and may slow the momentum of self-teaching when learning to read in English (Castles, Holmes, Neath, & Kinoshita, 2003). The motor-perceptual links and sensory integration established in letter writing help establish letter representations and associative links between printed letter forms and their sounds and names (Cunningham & Stanovich, 1990; Hulme, 1979; Hulme & Bradley, 1984; James, Jao, & Berninger, 2016; Longcamp, Anton, Roth, & Velay, 2003, 2005). In experiments to determine whether and how tracing letters helps children learn letter names (for the 3- and 4-year-olds) or abstract letter-like forms (for the older children), Hulme, Monk, and Ives (1987) found that tracing and naming the letter or symbol, compared with only naming the letter or symbol, improved children's PAL.

In the third treatment in the present study, we provided children with alphabet instruction comprised of basic PAL routines plus multiple experiences and practice in studying, forming, and writing letters. This orthographic referencing was designed to support children's learning of the orthographic component of paired associates between letter labels and letter forms by strengthening memory for letter shapes and a motor scheme for forming the letters.

Relation Between Features of Letter Names and Letter Sounds and Order of Alphabet Instruction

The relation between letter names and letter sounds, children's learning of each, the utility of each in learning to read, and the implications of these relations for the order in which letter names and letter sounds should be taught have engendered interest and debate among researchers and practitioners. Indeed, order of teaching letter names and letter sounds was so important in the United Kingdom that since 2007, their National Literacy Strategy requires teaching letter sounds before letter names (Rose, 2006). Ellefson, Treiman, and Kessler's (2009) descriptive comparison of U.S. and English children raised the interesting possibility that whichever learning occurs first (names or sounds) serves to bootstrap the other. This was based on evidence of letter name-to-sound facilitation for U.S. children who are more likely to learn names first, and letter sound-to-name facilitation for U.K. children who are more likely to learn sounds first. Although suggestive, group differences and the correlational nature of the findings leave these conclusions uncertain.

There are three features of alphabet knowledge that may influence the instructional effectiveness of teaching letter names or letter sounds first. The first is that most letters contain clues to their typical sounds (e.g., the name of the letter *B* features the /b/ sound in the initial position). The second feature is that the speech characteristics of letter names and letter sounds are different in ways that may influence ease of learning (e.g., the similarity of voicing and mouth position for the vowels makes them easily confusable). The third feature, derived from the first two, is that letter sounds are more difficult to learn than letter names.

Theory (Adams, 1990; Ehri, 1986) and research (e.g., Cardoso-Martins et al., 2011; Treiman & Tincoff, 1997; Treiman, Tincoff, Rodriguez, Mouzaki, & Francis, 1998) have indicated that knowledge of letter names helps children learn letter sounds. Most letter names contain some information about their sounds, and only a few do not (e.g., *W*, *Y*; Share, 2004; Treiman et al., 1998; Treiman, Weatherston, & Berch, 1994). Children may use letter names to learn letter sounds particularly for letters that have their sound at the beginning of their name (e.g., *B*, *V*; e.g., Share, 2004; Treiman et al., 2008). It may also be helpful to teach letter names first because speech production of them is less fleeting and more distinctive than is production of letter sounds (Boyer & Ehri, 2011; Ehri & Roberts, 2006; Piasta & Wagner, 2010b). In addition, letter names provide a whole word label that may help establish initial memories of letter and label pairings and efficient retrieval of names. This advantage may be particularly important for 3- and 4-year-old children whose representations of individual English phonemes are still developing, for children who have not had extensive exposure to the English alphabet and phonemes, and for children with lower levels of English vocabulary because vocabulary growth leads to refinement of phoneme representations (Metsala & Walley, 1998).

In contrast, letter sound knowledge is more directly involved in conventional literacy skills such as decoding and spelling than letter name knowledge, suggesting instruction in letter sounds may be more beneficial to later authentic reading and spelling. Moreover, letter names do not always map directly to phonemes in words, creating potential confusion in early decoding. We studied further the bootstrapping possibility of letter names, which may fundamentally modify current understanding of the relation between letter names and letter sounds and their instruction. If learning letter sounds is more difficult than learning letter names (Boyer & Ehri, 2011; Ehri & Roberts, 2006; Roberts, Vadasy, & Sanders, 2018; Treiman & Kessler, 2003), and if learning letter names bootstraps learning of letter sounds, this may suggest a principled sequence for teaching letter names and letter sounds. We examined this question by comparing two sequences of letter instruction: teaching either letter names or letter sounds first, followed by teaching the alternate sounds or names.

DLL Preschool Children

Effective instruction crafted to support DLLs in alphabet learning in order to capitalize on their potential to learn second-language phonemes and their associated letter names and letter sounds is necessary. There is a large and growing number of DLL children in U.S. schools (National Clearinghouse for English Language Acquisition, 2011). More than 66% of English learner children come from households with incomes below 200% of the federal poverty level (EPE Research Center, 2009). Spanish-speaking students are the largest subgroup of school-age English learners; in 2015, 75% of the total U.S. English learner student population spoke Spanish (Ruiz Soto, Hooker, & Batalova, 2015), and 2015 National Assessment of Educational Progress data report a 24-point gap in average reading scores between white and Hispanic fourth graders (National Center for Education Statistics, 2015).

Disparities in early literacy skills between DLLs and English-only students are present at school entry and influence later reading performance. Potential difficulty in perceiving and manipulating English phonemes, particularly when they are not present in the phonemic inventory of the first language, presents an added challenge in learning elusive letter sounds. Preschool teachers have reported uncertainty about how to teach phonological awareness and vocabulary skills to English learners (O'Leary, Cockburn, Powell, & Diamond, 2010).

Instruction that affords practice in oral production, with auditory feedback coming from this practice and teacher modeling of correct English sounds, and with frequent learning trials to increase English phoneme production practice (DeKeyser & Sokalski, 2001) should be helpful to young DLLs. A secondary question in this study is whether alphabet instruction that emphasizes PAL, or references AL or OL, bringing hand and mouth motor practice and focus to the task of learning alphabet abstractions, offers differential benefits for DLL preschool children.

Earlier Findings With Combined CLPs

In an earlier experimental training study (Roberts et al., 2018), we examined the content of alphabet teaching for preschool children in treatments where they were taught letter names only (LN-only), letter sounds only (LS-only), or letter names and letter sounds (LN+LS). Each experimental alphabet treatment incorporated activities that specifically enlisted PAL, AL, and OL. The combined experimental LN+LS instruction resulted in statistically significantly greater learning in both letter names and letter sounds compared with a business-as-usual LN+LS treatment. Because the experimental LN+LS instruction was most effective in the earlier study, we taught that double alphabet content in the current study.

Our purpose in the present study was to continue to identify effective features of alphabet instruction for both DLLs and non-DLLs by examining the individual contribution of incorporating different amounts of PAL, AL, or OL. Our hypothesis was that instruction that explicitly enlisted more visual–verbal PAL would most strongly facilitate English alphabet learning (Hulme et al., 2007; Litt et al., 2013; Litt & Nation, 2014). However, instruction that features more AL and OL may have differential effects on letter sound knowledge or letter writing, respectively. Finally, we examined the order for teaching letter names and letter sounds and whether teaching letter names first bootstraps learning of letter sounds.

Method

Research Sites

Four elementary schools were recruited in suburban districts near a Western U.S. city. The schools had a mix of half-day and full-day preschool classrooms, all with low-income family eligibility thresholds. Two school district–employed teachers with early childhood teaching certification were assigned to each classroom. Under a memorandum of understanding with the district, participating preschool teachers agreed to defer explicit whole-class alphabet instruction from late August until mid-December, when the study was completed. The following numbers of preschool teachers participated at the respective schools: four, four, two, and two.

Sample and Random Assignment Procedures

Randomization was performed after 106 four-year-old children were determined to be eligible based on letter name screening. Children who knew more than four of the letter names for the eight letters targeted for instruction were excluded. Children were randomly assigned within each of the eight classrooms into 27 small groups of three or four children each. Within each classroom, three small groups were assigned to one of the CLP conditions; the three extra groups were randomly assigned across classrooms. Finally, each small group within each classroom was randomly assigned to either letter names first or letter sounds first. The three CLP conditions were PAL only (PAL), PAL plus AL (PAL+AL), and PAL plus OL (PAL+OL), with nine small groups per condition. Attrition comprised 12 children: three in the PAL-only condition, five in the PAL+AL condition, and four in the PAL+OL condition.

The final sample of 94 children comprised 32 children (nine small groups; 13 DLLs) in PAL, 32 children (nine small groups; 13 DLLs) in PAL+AL, and 30 children (nine small groups; nine DLLs) in PAL+OL. There were 39 males and 55 females; 35 children were DLLs, and 59 were native English speakers (non-DLLs). DLL status was based on parent report that the child spoke a language other than English at home, and teacher confirmation. All children were administered the IDEA Pre-IPT Oral Language Proficiency Test (pre-IPT; Stevens, 2010), an assessment of overall English proficiency for children ages 3–5. Of the 35 DLL children in the study, 10 tested at level A, 16 at level B, four at level C, and five at level D. According to the testing manual, levels A–D correspond to non-English-speaking (level A) or limited English-speaking (levels B–D). The mean age at pretest was 4.08 years (SD = 0.56 year).

Training

A team of six research assistant assessors and instructors was made up of a former assessment coordinator, one graduate student, three experienced early childhood educators with master's degrees, and two trained elementary school teachers. The first author and project coordinator presented all trainings. In the training for the assessors, administration for each measure was demonstrated, and assessors practiced administering all assessments and received corrective feedback from researchers and peers. The training for instructors included demonstration of the teaching activities for each treatment. Training emphasized achieving high levels of response accuracy from the children, adding explicit verbal models for English learners, monitoring student progress, and prompting oral responses. Following the two full-day trainings, all research assistants spent time in the preschool classrooms in which they were assigned to meet the children and teachers and to familiarize children with grouping and assessment procedures.

Alphabet Content

Eight letters were selected for instruction: *T*, *A*, *D*, *M*, *H*, *S*, *L*, and *K*. Letters were chosen to balance letter features known to affect ease of learning: acrophonic (*T*, *D*, and *K*), nonacrophonic (*M*, *S*, and *L*), position in the alphabet (beginning: *A*, *D*, and *H*; middle: *K*, *L*, and *M*; end: *S* and *T*), most widely (*A*) and less well known (*H*) by young children, and those having greater visual distinctiveness. Eight letter names and eight letter sounds were taught in each condition. Two of the selected letter sounds do not overlap with the Spanish phonemic inventory. All letters were presented for instruction in uppercase because uppercase letters are easier than lowercase letters for preschool children to learn (Drouin, Horner, & Sondergeld, 2012).

Alphabet Instruction by CLP Emphasis

Children assigned to each of the three alphabet treatments received five weeks of Monday–Thursday instruction of the assigned CLP emphasis instruction (PAL only, PAL+AL, or PAL+OL) of either names or sounds, followed by five weeks of instruction in the other type of alphabet content (letter names or letter sounds). Two new letters names or letter sounds were introduced each week, followed by one week of review (approximately 20–24 minutes total for each letter name and letter sound; approximately four to five minutes for daily review and cumulative week's review for each letter name and letter sound). The same instructional routines were included in letter name first and letter sound first instruction. Instructors corrected errors and elicited responses from nonresponders. Lessons across treatments were equated for a duration of 10 to 12 minutes, for the number of teacher references to letters, and the number of times children were prompted to speak letter names and/or sounds. The Appendix (available as supporting information for the online version of this article) shows the features of instruction unique to each condition.

PAL-Only Instruction

Warm-Up Review

The instructor used 5″ × 8″ cards to review all letters taught to date. Children were prompted to respond chorally, and corrective feedback was provided.

Introduce the Letter

The instructor presented the new letter card: "This letter (name or sound) is ___. Say ___." Children were told to look at the letter and respond chorally.

Find the New Letter

The instructor presented cards for the new letter and three previously taught letters, handed one card to each child, and asked, "Who has the new letter (name or sound)?" The child with the new letter card showed it to the group, and children chorally said the label. The instructor repeated this procedure three times.

Find Your Letters

Given four small letter cards (the new letter and three previously taught letters) and a strip printed with four blank boxes, children were directed to "Put a letter in each box (in any order they chose). Point to the letter (name or sound). Say the letter (name or sound)." The sequence was repeated three times.

The Animal Game

Each child was given three small letter cards and a picture of an animal whose name began with the target letter (e.g., a kangaroo picture for the letter *K*). The instructor directed the children to "Close your eyes. Mix up the letters. Feed the (animal) letter (name or sound) ___ and say (name or sound)." Each child played the animal game four times.

Cumulative Review

Each child was given a small booklet containing the eight letters taught, one letter per page. Children were directed to point and chorally read each letter (name or sound) page by page that had been taught to date. Teachers provided correction or responses to individual children as needed. Children were taught to tap their head and say "Think, think" to help them reflect and regulate their inclination to sometimes call out the first letter name or sound that came to mind.

AL (PAL+AL) Instruction

Warm-Up Review

This was the same procedure used in the PAL-only instruction for each of the eight taught letter names and letter sounds.

Introduce the New Letter

The procedure was similar to PAL only. In addition, the instructor presented a mouth picture for the letter, said "Watch my mouth say the letter (name or sound)," said the letter while circling her mouth, and prompted children to chorally respond.

Articulation Referencing

Using the mouth picture of the new letter, the instructor first reviewed the mouth part labels as follows: "Say *tongue* (sticking out her tongue). Say *mouth* (circling her mouth). Say *lips* (puckering and pulling back her lips). Say *throat* (touching her throat). Say *teeth* (showing her teeth)." Children repeated the labels with the instructor once and then repeated the review. Next, the instructor showed how the new letter (name or sound) was articulated: "See how you say the letter (name or sound). Look at the mouth picture." She held the mouth picture below her mouth and said the name or sound, exaggerating her mouth movements. Children did this with the instructor two times. Next, the children were given small mirrors. The instructor modeled looking in the mirror while saying the new letter (name or sound): "Look at me. Think (tapping her head). Show how your mouth makes ___ (name or sound). Look at your mouth and say ___." Then, children were directed to "Look at the mouth movements that make letter (name or sound). Say ___." Children repeated saying the letter with their mirror three times.

The Animal Game

This was the same procedure used in the PAL-only instruction.

Cumulative Review

Each child had a small alphabet book containing the taught letters. In addition, the mouth picture for each letter being reviewed was presented. Children were directed to look at the mouth picture and point to and read each letter (name or sound) that had been taught to date. Teachers provided correction or responses to individual children as needed. Children were taught to tap their head and say "Think, think" to help them reflect and regulate their inclination to sometimes call out the first letter name or sound that came to mind.

OL (PAL+OL) Instruction

Warm-Up Review

This was the same procedure used in the PAL-only instruction for each of the eight taught letter names and letter sounds.

Introduce the New Letter

The procedure was similar to PAL only. In addition, the instructor modeled writing the letter while the children watched.

Orthographic Referencing

Placing the new letter card on a small easel, the instructor said, "See how you write the letter (name or sound). I'll write and say the lines for each letter." The letter forms were described with the terms *down*, *up*, *across*, *slant*, and *around*, which were taught in the first lessons. For example, when teaching the letter *M*, the instructor said the letter lines: "Down, slant, slant, down." Children used whiteboards and markers to practice following the instructor's model for copying and writing the letter and saying the lines. After doing this two times, children were directed to "Think (tap head). Write the new letter (name or sound). Say the lines and write." Children wrote the letter, saying the lines, three times. The instructor modeled writing the letter and saying the lines one more time and asked children to chorally say the name and sound.

The Animal Game

This was the same procedure used in the PAL-only instruction.

Cumulative Review

Each child had a small alphabet book containing the taught letters. Children were directed to point and trace on their letter card with their finger each letter (name or sound) that had been taught to date and then say the letter (name or sound). Teachers provided correction or responses to individual children as needed. Children were taught to tap their head and say "Think, think" to help them reflect and regulate their inclination to sometimes call out the first letter name or sound that came to mind.

Review Week Instruction

The week before the posttest, children in each treatment reviewed all eight taught letters (names and sounds). Each day, a different group of letters was reviewed. Basic activities were similar to the lesson activities in weeks 1–9 for each treatment. After being taught both letter names and letter sounds, children were reminded that letters have both names and sounds. The instructor provided several opportunities each review day for children to say both the name and the sound for each letter. The small letter book reading included reading each letter name and sound.

Treatment Integrity

To assess integrity of the three treatments, two measures were used: implementation observations and daily attendance. Implementation observations of each small group were conducted during the first and second half of the intervention. Observer reliability was established with dual codings of four small groups (each type of instruction) and reached 100% agreement. Elements of each lesson were coded as yes or no for correct treatment, letter content, and lesson activity. Instructional delivery was rated with a 3-point rating scale (1 = *low*; 3 = *high*) using the following criteria: begins on time and uses the full time allotted, materials organized, models letters correctly, ensures that all children are responding, engages and redirects as needed, warm and enthusiastic manner, and pacing maintains focus. A total of 27 observations were conducted across the three treatment groups in the first half of the intervention and 23 observations in the second half. Fidelity for correct treatment implementation for all three treatments was 100% and, for instructional delivery, averaged 2.99 (out of 3). Finally, treatment intensity averaged 36 lessons, with no statistically significant differences across groups or between DLL and non-DLL children.

Measures

We adapted standardized test measures for administration with young children by simplifying the language of test instructions, including one or two practice items and providing two success items at the end of each test. All children in participating classrooms were first screened on letter name identification. Measures were administered individually.

English-Language Oral Proficiency

This was measured at pretest only with the pre-IPT (Stevens, 2010), an age-appropriate assessment of English for children ages 3–5. The test was designed to follow a storyline, with opportunities for oral interaction between tester and child. Test materials include a large storyboard and story props. The tester uses the props to ask the child questions that require pointing, action, or verbal responses. Four domains of oral English are assessed: vocabulary, grammar, comprehension, and verbal expression. Raw scores range from 0 to 40. Reliability was .97.

Letter Name and Letter Sound Knowledge (Accuracy)

Taught and untaught letter name and letter sound knowledge were tested separately at pretest and posttest. The letters were separated into a deck of the taught letters (eight) and another deck of the untaught letters (18). The tester shuffled each deck prior to each administration. For each measure, the tester presented a card with a single printed uppercase letter and asked the child to identify either the letter name or letter sound. Order of assessing identification of letter names and letter sounds was counterbalanced. Sample item-level reliabilities for taught letter names was .53 at pretest and .81 at posttest, with a pretest–posttest correlation of .51. Reliabilities for taught letter sounds were .28 at pretest and .81 at posttest, with a pretest–posttest correlation of .12. Pretest reliabilities were depressed by large numbers of 0 scores.

Rapid Letter Naming (Fluency)

Children were tested separately on naming the eight taught letter names and letter sounds at pretest and posttest. For each test, children were presented an 8″ × 11″ card with 32 uppercase letters randomly arranged in rows (different arrangements for the names and sounds tests). Each of the taught letters appeared four times. Assessors modeled, and children repeated how to point and say each letter name or sound in a practice set of four untaught letters. Children were then asked to place their finger on the first letter and then to touch and say each letter's name or sound. Three seconds were allowed for each item. The score for each measure was the total number of letter names or sounds correct in 30 seconds. The scores range was from 0 to 32. Sample item-level reliabilities for rapid letter name naming were .65 at pretest and .92 at posttest; reliabilities for rapid letter sound naming were .75 at pretest and .88 at posttest.

Letter Writing

Children were tested on writing four taught letters at pretest and posttest: *T*, *A*, *S*, and *H*. The tester first modeled how to write the letter for two nontaught letters. For the test items, the tester asked children to "Write the letter (name or sound)." The letter-writing score was 1 point for each letter written (maximum letter writing score of 4 points). Sample item-level reliabilities were .59 at pretest and .75 at posttest, with a pretest–posttest correlation of .51.

CLP Measures

PAL

The PAL visual–verbal and verbal–visual tasks were adapted from Hulme et al. (2007) and Litt and colleagues (Litt et al., 2013; Litt & Nation, 2014). To adapt the verbal–visual task for the young children in this study, children were instructed to point to rather than draw the correct symbols. Two sets of three-item visual–verbal and verbal–visual paired associates were counterbalanced at pretest and posttest. Each pair consisted of a letter-like symbol paired with a one-syllable pseudoword (e.g., *fim*, *pel*). Children were taught the associations in one practice trial and then participated in five testing trials for each association in which they were shown the three abstract symbols and asked to either name a symbol (visual–verbal) or touch a symbol that the tester named (verbal–visual). Correction was given as needed after each item was presented, and the symbol and label were presented again for each pair for additional learning. The maximum score for each PAL task was 15. Sample item-level reliabilities across visual–verbal and verbal–visual sets (across sets A and B) averaged .81 at pretest and .73 at posttest, with a pretest–posttest correlation of .38.

AL

The task was drawn from the teaching tasks in Boyer and Ehri (2011). Children were taught the phonemes represented by photographs of mouth shapes. The test items featured pictures of mouth articulation for the letters *M*, *F*, *H*, *S*, and *T*. There were two practice items (*W* and *J*) and five learning trials. For each trial, children were asked to speak the phoneme for each of the five mouth pictures. Errors and nonresponses were retaught during each trial. The maximum score was 25 points. Sample item-level reliabilities at pretest and posttest were .92 and .88, respectively; the pretest–posttest correlation was .47.

OL

The task is an adaptation of Apel et al.'s (2006) orthographic learning measure (mental graphemic representations). Task materials were four short stories, including an initial practice story. The adapted stories featured four nonword items with high-phonotactic/high-orthotactic features (*hess*, *chan*, *thug*, and *gove*). Four-page stories with pictures and the target word printed in bolded capital letters were read (e.g., "A **HESS** is red"). The target picture was quickly pointed to right after the word was spoken and pointed to. After the story, children were shown a card with three foils and the target word, shown the picture of the item, and asked to touch the word on the card that named it. The maximum score was 4 points. Sample item-level reliabilities at pretest and posttest were close to 0; however, for conceptual reasons, it was not excluded from analyses.

Data Analysis Approach

A multilevel modeling (mixed-modeling) approach was adopted because the appropriate primary unit of analysis is the small group, rather than child, given that instructional conditions were implemented in small groups. Further, the multilevel approach accounts for the magnitude of the nesting (nonindependence) of small-group variation within teachers. All models were estimated using SAS 9.4 PROC MIXED procedure and Satterthwaite degrees of freedom for fixed-effects tests.

Preliminary Analyses

Preliminary analyses entailed testing for any preexisting differences among instructional conditions, instructional orders, and DLLs versus non-DLLs, using three-level models (children nested within small groups, within teachers). Although DLL children were statistically significantly lower than their non-DLL peers on language skills (pre-IPT) and on one of the CLP measures (PAL) ($ps < .001$), there were no statistically significant differences found for condition, order, or DLL status on any other pretest ($ps > .05$).

Finally, intercept-only models were estimated to determine the level of dependencies in the data (i.e., intraclass correlations). Results showed that children's teachers explained 0–12% of variation in pretests, 0–4% in posttests, and 0–14% in pretest–posttest gains. Children's small groups (within classrooms) explained 0–11% of variation in pretests, 0–20% in posttests, and 0–13% in pretest–posttest gains.

Alphabet Outcome Models

Alphabet outcome models were specified to test for instructional condition effects at the small-group level, controlling for pretest language and pretest letter name knowledge at the child level, on pretest–posttest gains (Connor et al., 2017). These models also tested the effects of instructional order (letter names first vs. letters sounds first, at the small-group level), DLL status (at the child level), and interactions. For ease of results interpretation, categorical predictors were effect-coded, and continuous predictors were standardized. Specifically, the three instructional conditions were effect-coded into a set of two predictors, with the first testing whether PAL had statistically significant greater gains than the mean gain (PAL = 1; PAL+AL = 0; PAL+OL = −1) and the second testing whether PAL+AL had statistically significantly greater gains than the mean gain (PAL = 0; PAL+AL = 1; PAL+OL = −1). In other words, PAL+OL served as the reference condition. Just as in unilevel regression modeling, our choice of reference condition does not change model fit, model parameter estimates, or model-based predicted values for any condition; it only specifies which condition's gain will be directly tested against the average gain. Order was effect-coded as 1 = *letter names first* and −1 = *letter sounds first*, and DLL was effect-coded as 1 = *DLL* and −1 = *non-DLL*. Pretest language (using the pre-IPT) and pretest alphabet knowledge (total letters correctly named) were standardized in z-scores. Our general mixed model for each of our five alphabet outcomes was as follows:

$$
\begin{aligned}
\text{Pre–postgain}_{ijk} = {} & \gamma_{000} + \gamma_{100} * \text{ZPre-IPT}_{ijk} + \\
& \gamma_{200} * \text{ZPreLetters}_{ijk} + \gamma_{300} * \text{ZDLLeffect}_{ijk} + \\
& \gamma_{010} * \text{PALeffect}_{jk} + \gamma_{020} * \text{ALeffect}_{jk} + \\
& \gamma_{030} * \text{Ordereffect}_{jk} + \gamma_{040} * \text{PAL} * \text{Order}_{jk} + \\
& \gamma_{050} * \text{AL} * \text{Order}_{jk} + \gamma_{310} * \text{PAL}_{jk} * \text{DLL}_{ijk} + \\
& \gamma_{320} * \text{AL}_{jk} * \text{DLL}_{ijk} + \\
& \gamma_{330} * \text{Order}_{jk} * \text{DLL}_{ijk} + \\
& \gamma_{340} * \text{PAL} * \text{Order}_{jk} * \text{DLL}_{ijk} + \\
& \gamma_{350} * \text{AL} * \text{Order}_{jk} * \text{DLL}_{ijk} + \\
& U_{00k} + U_{0jk} + \gamma_{ijk}
\end{aligned}
$$

In this model, the pretest–posttest gain for the ith student in the jth small group in the kth teacher's classroom is estimated as equal to the sum of the conditional mean gain (γ_{000}), the child-level effects of pretest language (pre-IPT) and alphabet knowledge (letter names) on gains in standard deviations ($\gamma_{100} - \gamma_{200}$), the child-level effect of DLL status (γ_{300}), the small-group-level effects of instructional condition ($\gamma_{010} - \gamma_{020}$) and order ($\gamma_{030}$) and their interactions ($\gamma_{040} - \gamma_{050}$), all cross-level interactions between child DLL status and small-group instructional condition and order ($\gamma_{310} - \gamma_{350}$), and the residual errors among teachers, small groups, and children (U_{00k}, U_{0jk}, and r_{ijk}).

CLP Measure Models

Our second set of models focused on the CLP measure pretest–posttest gains. These models were nearly identical to those for the alphabet outcomes, but CLP's respective pretest was used as a covariate (standardized in z-scores) instead of pretest alphabet knowledge.

Pairwise Comparisons

For the alphabet and CLP models, pairwise comparisons of the three instructional conditions, as well as simple effects for any statistically significant interaction, were conducted using the LSMEANS statement within the PROC MIXED procedure of SAS 9.4. For these comparisons, we computed an approximate effect size as the difference between conditions in standard deviations, determined by dividing the model-estimated mean difference by the approximate pooled standard deviation. The approximate pooled standard deviation was computed by dividing the model-based standard error of the differences between means (approximate *SE*) by the square root of the inverse of three (conditions) divided by the total number of children (i.e., $SE \div \sqrt{(3/94)}$). To avoid inflating Type I error from three pairwise comparisons for each outcome, we employed a Dunn–Šidák *p*-value adjustment such that our per-comparison *p*-value threshold for statistical significance is .017 rather than .05.

Results

Descriptive Statistics

Table 1 displays descriptive statistics for pretests, posttests, and pretest–posttest gains for each condition by DLL status. The sample averaged a mean of 66.44 (standard deviation [*SD*] = 28.36) on the norm-referenced (age-adjusted) standard score of the pre-IPT, which translates to rank below the 18th percentile nationally (below the 23rd percentile for non-DLLs and below the ninth percentile for DLLs). Zero-order correlations among all variables used in analyses are provided in Table 2 for both DLLs (above the diagonal) and non-DLLs (below the diagonal), but we note that these correlations are not adjusted for dependencies in the data.

Alphabet Outcomes Results

Mean Pretest—Posttest Gains and Covariate Effects

Table 3 displays the fixed-effects model results for each of the alphabet outcomes. First, we focus on the top three rows of information (i.e., mean gains, covariate effects). The estimated mean pretest–posttest gains, across all children and conditions, were statistically significantly greater than zero for each of the alphabet outcomes, with mean gains estimated at 2.42 taught letter names gained, 3.10 taught letter sounds gained, 3.50 rapid letter names gained, 4.14 rapid letter sounds gained, and 0.97 letter written gained. There were possible scores of 8, 8, 26, 26, and four letters on each of these measures, respectively; thus, children were predicted to gain 30% on taught letter names, 39% on taught letter sounds, 13% on rapid letter names, 17% on rapid letter sounds, and 24% on letter writing from pretest to posttest.

Pretest overall English proficiency skill positively predicted all but one (taught letter names) of the five outcomes, and pretest letter name knowledge also positively predicted all but one (taught letter sounds) of the five outcomes. Specifically, for every standard deviation increase in pretest language skill, there was a predicted advantage of 0.83 letter gained from pretest to posttest in taught letter sounds, 1.44 letters gained in rapid letter names, 1.61 letters gained in rapid letter sounds, and 0.40 letter gained in letter writing. Similarly, for every standard deviation increase in pretest letter name knowledge, there was a predicted advantage of 0.54 letter gained in taught letter names, 1.58 letters gained in rapid letter names, 0.88 letter gained in rapid letter sounds, and 0.29 letter gained in letter writing. The bottom portion of the fixed-effects alphabet model results (see Table 3) showed that there was no statistically significant DLL effect on pretest–posttest gains, controlling for pretest language skill and letter name knowledge.

Instructional Condition Effects

The results in the middle rows of Table 3 show a main effect of PAL only across all but one (letter writing) of the five alphabet outcomes. However, the main effect was moderated by a consistent interaction between DLL status and instructional condition on all of the alphabet outcomes. Pairwise comparisons (see Table 4) of the adjusted means of the three instructional conditions by DLL status (illustrated in Figure 1), adjusted for multiple group comparisons, showed that the PAL-only condition was consistently advantageous for non-DLL children compared with both PAL+AL and PAL+OL conditions on four measures: letter name and letter sound identification accuracy and rapid identification of letter names and letter sounds. The associated effect sizes were moderate and ranged from 0.51 to 0.67. The largest effect size (0.67) in favor of the PAL-only condition was on letter sound identification. In contrast, for DLL children, there were no statistically significant differences between conditions (see Table 4).

We performed a post hoc analysis comparing children's learning of taught and untaught letter names and letter sounds to evaluate the extent to which pretest–posttest gains on letter name and letter sound identification were due to instruction. We computed the percentage gain from pretest to posttest for the eight taught and 18 untaught letter names and letter sounds. These gain percentages were arcsin transformed and then compared for both DLL and non-DLL children. For both DLL and non-DLL children, both letter name and letter sound gains were statistically significantly higher for the taught

TABLE 1
Simple (Unadjusted) Means and Standard Deviations by Instructional Condition

Measure (observed range)	PAL (*n* = 32)			PAL+AL (*n* = 32)			PAL+OL (*n* = 30)		
	Pretest *M* (*SD*)	Posttest *M* (*SD*)	Gain *M* (*SD*)	Pretest *M* (*SD*)	Posttest *M* (*SD*)	Gain *M* (*SD*)	Pretest *M* (*SD*)	Posttest *M* (*SD*)	Gain *M* (*SD*)
Pre-IPT (0–38)	14.56 (11.61)			14.88 (11.88)			17.13 (12.20)		
• DLL children	10.54 (12.27)			11.31 (9.89)			5.56 (3.43)		
• Non-DLL children	17.32 (10.59)			17.32 (12.74)			22.10 (11.18)		
Total letters (0–14)	2.03 (3.07)			1.44 (2.79)			1.43 (2.10)		
• DLL children	2.23 (3.19)			0.62 (1.71)			1.00 (1.66)		
• Non-DLL children	1.89 (3.07)			2.00 (3.27)			1.62 (2.27)		
Taught letter names (0–8)	0.38 (0.83)	3.75 (2.79)	3.38 (2.59)	0.41 (0.87)	2.34 (2.28)	1.94 (1.88)	0.47 (0.90)	2.47 (2.26)	2.00 (1.80)
• DLL children	0.31 (0.75)	2.46 (2.57)	2.15 (2.03)	0.15 (0.55)	1.46 (1.51)	1.31 (1.55)	0.33 (1.00)	2.44 (1.94)	2.11 (1.45)
• Non-DLL children	0.42 (0.90)	4.63 (2.65)	4.21 (2.64)	0.58 (1.02)	2.95 (2.55)	2.37 (2.01)	0.52 (0.87)	2.48 (2.42)	1.95 (1.96)
Taught letter sounds (0–8)	0.19 (0.40)	4.41 (2.67)	4.22 (2.73)	0.19 (0.54)	2.44 (2.60)	2.25 (2.55)	0.03 (0.18)	2.87 (1.93)	2.83 (1.86)
• DLL children	0.15 (0.38)	3.23 (2.62)	3.08 (2.81)	0.15 (0.55)	1.77 (1.74)	1.62 (1.89)	0.00 (0.00)	3.22 (2.49)	3.22 (2.49)
• Non-DLL children	0.21 (0.42)	5.21 (2.46)	5.00 (2.45)	0.21 (0.54)	2.89 (3.02)	2.68 (2.89)	0.05 (0.22)	2.71 (1.68)	2.67 (1.56)
Rapid letter names (0–24)	0.34 (0.83)	5.63 (6.32)	5.28 (5.77)	0.59 (1.34)	3.81 (5.03)	3.22 (4.49)	0.53 (1.04)	2.70 (3.88)	2.17 (3.68)
• DLL children	0.23 (0.60)	3.31 (3.84)	3.08 (3.35)	0.15 (0.55)	2.46 (3.38)	2.31 (3.50)	0.22 (0.67)	1.89 (1.76)	1.67 (2.00)
• Non-DLL children	0.42 (0.96)	7.21 (7.24)	6.79 (6.62)	0.89 (1.63)	4.74 (5.80)	3.84 (5.06)	0.67 (1.15)	3.05 (4.49)	2.38 (4.22)
Rapid letter sounds (0–18)	0.06 (0.25)	5.81 (4.90)	5.75 (4.87)	0.25 (1.02)	3.44 (4.23)	3.19 (3.90)	0.03 (0.18)	3.43 (2.64)	3.40 (2.65)
• DLL children	0.00 (0.00)	4.08 (3.84)	4.08 (3.84)	0.00 (0.00)	2.62 (2.02)	2.62 (2.02)	0.11 (0.33)	3.44 (3.50)	3.33 (3.54)
• Non-DLL children	0.11 (0.32)	7.00 (5.27)	6.89 (5.25)	0.42 (1.30)	4.00 (5.23)	3.58 (4.80)	0.00 (0.00)	3.43 (2.27)	3.43 (2.27)
Letter writing (0–4)	0.13 (0.42)	1.22 (1.36)	1.09 (1.28)	0.06 (0.35)	0.91 (1.20)	0.84 (1.08)	0.10 (0.40)	1.07 (1.17)	0.97 (0.96)
• DLL children	0.15 (0.55)	0.77 (1.24)	0.62 (1.19)	0.00 (0.00)	0.69 (0.95)	0.69 (0.95)	0.00 (0.00)	0.78 (0.97)	0.78 (0.97)
• Non-DLL children	0.11 (0.32)	1.53 (1.39)	1.42 (1.26)	0.11 (0.46)	1.05 (1.35)	0.95 (1.18)	0.14 (0.48)	1.19 (1.25)	1.05 (0.97)
PAL (0–24)	9.28 (5.46)	15.25 (5.42)	5.97 (4.69)	8.41 (4.23)	14.25 (3.70)	5.84 (5.47)	9.40 (5.56)	13.67 (3.56)	4.27 (5.70)
• DLL children	6.85 (4.65)	14.08 (5.22)	7.23 (2.89)	8.08 (3.73)	13.08 (4.15)	5.00 (5.12)	8.00 (3.84)	14.33 (4.53)	6.33 (4.95)
• Non-DLL children	10.95 (5.45)	16.05 (5.54)	5.11 (5.51)	8.63 (4.63)	15.05 (3.22)	6.42 (5.77)	10.00 (6.14)	13.38 (3.14)	3.38 (5.88)
AL (0–25)	8.09 (6.63)	16.94 (3.85)	8.84 (5.71)	7.41 (5.02)	14.91 (5.50)	7.50 (4.00)	8.30 (5.26)	15.03 (4.02)	6.73 (6.07)
• DLL children	7.23 (6.51)	17.08 (4.65)	9.85 (6.39)	6.62 (5.09)	15.08 (4.17)	8.46 (4.24)	6.44 (4.93)	16.22 (3.07)	9.78 (5.14)
• Non-DLL children	8.68 (6.82)	16.84 (3.34)	8.16 (5.27)	7.95 (5.03)	14.79 (6.36)	6.84 (3.80)	9.10 (5.31)	14.52 (4.33)	5.43 (6.07)

(*continued*)

TABLE 1
Simple (Unadjusted) Means and Standard Deviations by Instructional Condition (*continued*)

Measure (observed range)	PAL (n = 32)			PAL+AL (n = 32)			PAL+OL (n = 30)		
	Pretest *M* (*SD*)	Posttest *M* (*SD*)	Gain *M* (*SD*)	Pretest *M* (*SD*)	Posttest *M* (*SD*)	Gain *M* (*SD*)	Pretest *M* (*SD*)	Posttest *M* (*SD*)	Gain *M* (*SD*)
OL (0–3)	0.97 (0.74)	1.19 (0.93)	0.22 (1.26)	1.00 (0.76)	1.22 (0.83)	0.22 (1.07)	0.93 (0.64)	0.97 (0.93)	0.03 (1.10)
• DLL children	1.23 (0.73)	1.23 (0.73)	0.00 (0.91)	0.92 (0.76)	1.08 (0.64)	0.15 (0.90)	0.78 (0.44)	1.00 (1.12)	0.22 (1.39)
• Non-DLL children	0.79 (0.71)	1.16 (1.07)	0.37 (1.46)	1.05 (0.78)	1.32 (0.95)	0.26 (1.19)	1.00 (0.71)	0.95 (0.86)	−0.05 (0.97)

Note. AL = articulatory learning; DLLs = dual-language learner; *M* = mean; observed range = observed range of scores in the sample; OL = orthographic learning; PAL = paired-associate learning; pre-IPT = IDEA Pre-IPT Oral Language Proficiency Test (Stevens, 2010); *SD* = standard deviation. N = 94 preschool children within 27 small groups and eight teacher classrooms. For the DLL children, PAL n = 13 (41%); PAL+AL n = 13 (41%); PAL+OL n = 9 (30%).

letters than the untaught letters; for DLL letter names, $t(34) = 6.10$, $p < .000$; for non-DLL letter names, $t(59) = 7.38$, $p < .000$. For DLLs, the mean for taught letter names was 0.23 ($SD = 0.22$), and for untaught letter names, it was 0.05 ($SD = 0.14$). For non-DLLs, the mean for taught letter names was 0.35 ($SD = 0.30$), and for untaught letter names, it was 0.10 ($SD = 0.15$). For letter sounds, the results of the t-test comparisons was $t(34) = 6.08$ ($p < .000$) for DLLs, and for non-DLLs, $t(59) = 10.30$ ($p < .000$). For DLLs, the mean for taught letter sounds was 0.32 ($SD = 0.31$), and for untaught letter sounds, it was 0.02 ($SD = 0.04$). For non-DLLs, the mean for taught letter sounds was 0.43 ($SD = 0.32$), and for untaught letter sounds, it was 0.03 ($SD = 0.09$).

Order of Letter Name and Letter Sound Instruction Effects

There was no main effect of instructional order (letter names first vs. letter sounds first) detected for any of the alphabet outcomes. However, a statistically significant interaction between order and condition was found for identification of taught letter sounds and rapid letter sounds. Simple effects tests comparing the two orders within each of the three conditions showed that for the PAL-only condition, the second type of instructional order (letter sounds first) resulted in greater gains in pretest–posttest letter sound identification accuracy and speed than did the first order (letter names first; for taught letter sounds: by 1.87 letters, unadjusted $p = .028$; for rapid letter sounds: by 3.19 letters, unadjusted $p = .014$).

CLP Measures Results

The second set of models focused on the individual CLP measures and only differed from the alphabet outcome models in that each of the CLP measures' respective pretests replaced pretest letter name knowledge. Results (see Table 5) showed that children made statistically significant pretest–posttest gains on two of the three CLP measures (PAL and AL) and that each of the CLP pretests statistically significantly negatively predicted gains. More specifically, for every standard deviation increase in pretest, there is a predicted 3.60 fewer points gain on PAL, 3.56 fewer points gain on AL, and 0.70 fewer point gain on the OL, all else held constant. Pairwise tests revealed no statistically significant differences in CLP gains among the three conditions. The correlations between CLP initial status, CLP gains, and alphabet learning revealed that for DLLs, there were modest positive correlations between PAL initial status and gains in rapid letter sound identification and letter writing. For DLLs, there were also statistically significant but modest positive correlations between initial AL status and gains in letter name identification, letter sound identification, and rapid letter sound identification. These correlations were not statistically significant for non-DLLs. Finally, gains in CLPs from pretest to posttest were not correlated with any measure of alphabet learning.

Discussion

We designed this study to investigate the effects of two important features of alphabet letter instruction on alphabet learning. One feature was the degree of emphasis during instruction on PAL, AL, and OL processes underlying alphabet learning. The second feature was the order of letter name or letter sound instruction. A major finding was that instruction including the most PAL had distinct learning advantages. A second important finding was that we detected no advantage for teaching letter names before letter sounds and some indication that teaching letter sounds first might be advantageous. Language status moderated these relations. We endeavored to better understand how treatments may have worked and how learning may have occurred by measuring individual differences in the three CLPs at pretest and gains at posttest, and their relation to instruction and alphabet learning. Detailing of these findings follows.

TABLE 2
Zero-Order Correlations for Variables in Models

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Condition																	
1. Instruction: PAL vs. else	—	**−.59**	**−.45**	.08	.08	.30	−.15	.06	.26	.15	.16	.16	.18	−.05	.19	.08	−.09
2. Instruction: PAL+AL vs. else	**−.48**	—	**−.45**	−.16	.14	−.23	.09	−.03	−.09	−.24	−.30	−.03	−.18	.01	−.21	−.13	.03
3. Instruction: PAL+OL vs. else	**−.51**	**−.51**	—	.08	−.24	−.08	.06	−.04	−.19	.10	.16	−.15	.00	.05	.02	.05	.06
4. Order: Letter names first vs. letter sounds first	−.17	.20	−.03	—	.08	.28	.03	.06	−.17	.23	−.06	−.06	−.20	.13	−.03	.01	**.34**
Pretest covariate																	
5. Pre-IPT	−.10	−.10	.20	.01	—	.12	**.37**	**.47**	−.19	−.01	.04	**.49**	.31	.19	−.11	−.31	.22
6. Total letter names	.02	.04	−.06	.03	**.36**	—	−.15	.27	.00	.16	−.14	.27	−.09	.18	.24	.06	.18
7. CLP: PAL	.14	−.16	.02	−.05	**.41**	.19	—	.12	−.14	−.24	−.17	−.03	−.21	.27	**−.41**	−.20	.16
8. CLP: AL	.01	−.08	.07	.10	.23	.09	**.27**	—	−.27	.04	−.09	**.41**	−.07	.22	.30	**−.71**	.05
9. CLP: OL	−.15	.10	.05	.03	**.28**	.11	.14	.15	—	−.10	−.09	−.24	.01	−.13	.25	**.39**	**−.63**
Pretest–posttest gain																	
10. Taught letter names	**.41**	−.13	**−.27**	−.12	.16	**.32**	.18	**.26**	−.08	—	**.47**	.33	**.35**	.27	.04	.19	.01
11. Taught letter sounds	**.43**	−.20	−.22	−.05	.20	.24	.19	**.33**	−.05	**.57**	—	.26	**.75**	.14	.21	.26	−.07
12. Rapid letter names	**.31**	−.05	−.25	.10	.23	**.39**	.18	.08	−.01	**.69**	**.47**	—	**.39**	.19	−.12	−.12	.15
13. Rapid letter sounds	**.36**	−.16	−.20	.03	**.31**	**.36**	**.28**	**.28**	.09	**.41**	**.76**	**.43**	—	−.10	.25	.29	−.10
14. Letter writing	.18	−.12	−.06	.08	**.44**	**.41**	**.36**	.23	.13	**.51**	**.44**	**.59**	**.50**	—	−.15	−.05	.01
15. CLP: PAL	.02	.18	−.20	.11	**−.30**	−.07	**−.73**	−.04	−.10	.13	.01	.14	−.08	−.07	—	−.03	**−.45**
16. CLP: AL	.19	.01	−.19	−.06	−.04	.13	−.01	**−.61**	−.06	.08	.02	.25	.07	.03	.09	—	−.12
17. CLP: OL	.11	.04	−.15	.11	−.09	.05	−.23	−.06	**−.61**	.19	−.02	.12	−.13	−.01	.22	.06	—

Note. AL = articulatory learning; CLP = cognitive learning process; OL = orthographic learning; PAL = paired-associate learning; pre-IPT = IDEA Pre-IPT Oral Language Proficiency Test (Stevens, 2010). Results for dual-language learners (n = 35) are above the diagonal, and results for non-dual-language learners (n = 59) are below the diagonal. Correlations statistically significant at the .05 level are in boldface. Correlations are not adjusted for dependencies in the data.

Relative Emphasis on PAL, AL, and OL in Alphabet Instruction

Interpretation of the findings should be couched in the proper context that instruction was equated for time across all three conditions and that PAL, obligatory in learning letter names and letter sounds, occurred in all three conditions. Therefore, we conclude that more PAL learning in which the relation between the letter form and its verbal label (spoken name or sound) was emphasized was more effective for non-DLL children than was (a) instruction with less PAL plus attention to the verbal label component of the pair (PAL+AL) or (b) instruction with less PAL plus more attention to the letter form component of each pair (PAL+OL). PAL+OL instruction, the only condition that included letter writing instruction, did not lead to better letter writing or better letter identification accuracy or speed. For the non-DLL children, the PAL+OL and PAL+AL multisensory treatment features may not have offset the strength of having more PAL.

TABLE 3
Fixed-Effects Model Results for Pretest—Posttest Gains on Alphabet Outcomes

	Taught letter names					Taught letter sounds					Rapid letter names					Rapid letter sounds					Letter writing				
Fixed effect	Coefficient	*SE*	*t*	*df*	*p*	Coefficient	*SE*	*t*	*df*	*p*	Coefficient	*SE*	*t*	*df*	*P*	Coefficient	*SE*	*t*	*df*	*p*	Coefficient	*SE*	*t*	*df*	*p*
Mean pretest–posttest gain	**2.42**	**0.26**	**9.36**	**67**	**<.001**	**3.10**	**0.37**	**8.40**	**8**	**<.001**	**3.50**	**0.44**	**8.03**	**94**	**<.001**	**4.14**	**0.39**	**10.65**	**6**	**<.001**	**0.97**	**0.11**	**8.86**	**29**	**<.001**
Pre-IPT (*Z*)	0.35	0.23	1.55	92	.124	**0.83**	**0.26**	**3.23**	**91**	**.002**	**1.44**	**0.49**	**2.95**	**94**	**.004**	**1.61**	**0.41**	**3.95**	**93**	**<.001**	**0.40**	**0.12**	**3.48**	**90**	**.001**
Pretest letters (*Z*)	**0.54**	**0.21**	**2.52**	**89**	**.013**	0.26	0.24	1.10	89	.273	**1.58**	**0.46**	**3.44**	**94**	**.001**	**0.88**	**0.38**	**2.31**	**90**	**.023**	**0.29**	**0.11**	**2.71**	**93**	**.008**
Instruction: PAL (−1 = OL)	**0.73**	**0.28**	**2.63**	**94**	**.010**	**1.00**	**0.31**	**3.21**	**89**	**.002**	**1.49**	**0.60**	**2.47**	**94**	**.015**	**1.44**	**0.50**	**2.87**	**91**	**.005**	0.08	0.15	0.54	28	.595
Instruction: PAL+AL (−1 = OL)	−0.42	0.28	−1.51	94	.134	**−0.95**	**0.31**	**−3.03**	**87**	**.003**	−0.42	0.61	−0.69	94	.489	**−1.06**	**0.51**	**−2.09**	**86**	**.040**	−0.09	0.15	−0.61	29	.549
Order	0.00	0.20	0.01	72	.990	−0.23	0.23	−1.01	92	.314	0.09	0.43	0.22	94	.830	−0.32	0.36	−0.89	94	.376	0.10	0.11	0.90	29	.376
• PAL*Order	−0.10	0.31	−0.33	83	.746	−0.70	0.36	−1.95	89	.054	−0.68	0.63	−1.08	94	.285	**−1.27**	**0.53**	**−2.38**	**53**	**.021**	−0.05	0.16	−0.32	31	.755
• PAL+AL*Order	0.36	0.32	1.13	79	.262	**0.76**	**0.38**	**2.00**	**77**	**.049**	0.96	0.64	1.51	94	.133	**1.29**	**0.54**	**2.37**	**36**	**.023**	0.03	0.16	0.18	33	.859
DLL	−0.29	0.22	−1.32	90	.190	0.00	0.25	−0.01	88	.992	−0.10	0.48	−0.20	94	.840	0.28	0.40	0.69	88	.493	−0.02	0.11	−0.21	93	.836
• DLL*PAL	**−0.70**	**0.28**	**−2.50**	**90**	**.014**	**−0.71**	**0.31**	**−2.30**	**88**	**.024**	**−1.42**	**0.60**	**−2.37**	**94**	**.020**	**−1.14**	**0.50**	**−2.27**	**88**	**.026**	**−0.30**	**0.14**	**−2.12**	**87**	**.037**
• DLL*PAL+AL	0.13	0.30	0.43	93	.669	−0.03	0.34	−0.10	94	.921	0.48	0.62	0.77	94	.441	0.20	0.52	0.38	86	.706	0.13	0.15	0.88	94	.383
• DLL*Order	0.18	0.20	0.88	93	.382	−0.21	0.23	−0.93	92	.353	−0.72	0.43	−1.67	94	.099	−0.71	0.36	−1.96	94	.053	−0.03	0.10	−0.34	93	.736
• DLL*PAL*Order	−0.30	0.28	−1.06	92	.292	−0.48	0.32	−1.52	91	.132	−0.47	0.60	−0.78	94	.436	−0.17	0.50	−0.33	94	.744	−0.18	0.14	−1.23	89	.222
• DLL*PAL+AL*Order	0.22	0.29	0.77	90	.444	0.18	0.32	0.55	90	.583	−0.14	0.61	−0.23	94	.822	0.08	0.51	0.16	92	.873	0.00	0.15	0.03	92	.974
Random effect	Variance	*SE*	*Z*		*p*	Variance	*SE*	*Z*		*p*	Variance	*SE*	*Z*		*P*	Variance	*SE*	*Z*		*p*	Variance	*SE*	*Z*		*p*
Teachers	0.21	0.29	0.74		.229	0.69	0.55	1.26		.105	<0.01					0.16	0.72	0.22		.414	<0.01				
Small groups (teachers)	<0.01					<0.01					<0.01					<0.01					0.05	0.09	0.51		.304
Residual	3.26	0.50	6.47		<.001	4.00	0.61	6.52		<.001	15.46	2.25	6.86		<.001	10.67	1.68	6.37		<.001	0.83	0.14	5.75		<.001

Note. AL = articulatory learning; *df* = degrees of freedom; DLL = dual-language learner; OL = orthographic learning; PAL = paired-associate learning; pre-IPT = IDEA Pre-IPT Oral Language Proficiency Test (Stevens, 2010); *SE* = standard error. *N* = 94 preschool children within 27 small groups and eight teacher classrooms. Statistically significant tests at the .05 level are in boldface.

TABLE 4
Pairwise Comparisons of Instructional Conditions on Adjusted Mean Gains

Measure	PAL Adj. *M*	PAL+AL Adj. *M*	PAL+OL Adj. *M*	PAL vs. PAL+AL						PAL vs. PAL+OL						PAL+AL vs. PAL+OL					
				Difference	*SE*	*t*	*df*	*p*	ES	Difference	*SE*	*t*	*df*	*p*	ES	Difference	*SE*	*t*	*df*	*p*	ES
All children																					
Taught letter names	3.16	2.00	2.11	**1.16**	**0.48**	**2.43**	**87**	**.017**	**.43**	1.04	0.50	2.09	93	.040	.37	−0.11	0.50	−0.23	90	.821	−.04
Taught letter sounds	4.10	2.15	3.05	**1.95**	**0.53**	**3.68**	**87**	**<.001**	**.66**	1.06	0.56	1.89	91	.062	.34	−0.89	0.56	−1.59	90	.116	−.28
Rapid letter names	4.99	3.08	2.44	1.91	1.03	1.85	94	.068	.33	2.55	1.07	2.39	94	.019	.43	0.64	1.08	0.59	94	.554	.11
Rapid letter sounds	5.58	3.09	3.76	**2.49**	**0.86**	**2.90**	**86**	**.005**	**.52**	1.82	0.89	2.03	94	.045	.36	−0.67	0.90	−0.75	91	.457	−.13
Letter writing	1.06	0.88	0.99	0.18	0.26	0.67	28	.508	.12	0.07	0.27	0.26	29	.796	.05	−0.10	0.27	−0.38	30	.704	−.07
Non-DLL children																					
Taught letter names	4.15	2.17	1.84	**1.98**	**0.63**	**3.16**	**93**	**.002**	**.57**	**2.31**	**0.59**	**3.90**	**90**	**<.001**	**.70**	0.33	0.63	0.52	94	.602	.09
Taught letter sounds	4.82	2.19	2.30	**2.63**	**0.70**	**3.74**	**92**	**<.001**	**.67**	**2.52**	**0.66**	**3.81**	**89**	**<.001**	**.68**	−0.11	0.71	−0.15	93	.878	−.03
Rapid letter names	6.51	2.70	1.59	**3.81**	**1.33**	**2.86**	**94**	**.005**	**.51**	**4.92**	**1.27**	**3.87**	**94**	**<.001**	**.69**	1.11	1.32	0.84	94	.403	.15
Rapid letter sounds	6.44	2.62	2.55	**3.83**	**1.12**	**3.43**	**94**	**.001**	**.61**	**3.89**	**1.06**	**3.67**	**92**	**<.001**	**.65**	0.07	1.11	0.06	92	.951	.01
Letter writing	1.38	0.78	0.84	0.61	0.33	1.84	49	.072	.33	0.54	0.32	1.72	46	.092	.31	−0.06	0.33	−0.19	46	.848	−.03

(*continued*)

TABLE 4
Pairwise Comparisons of Instructional Conditions on Adjusted Mean Gains (*continued*)

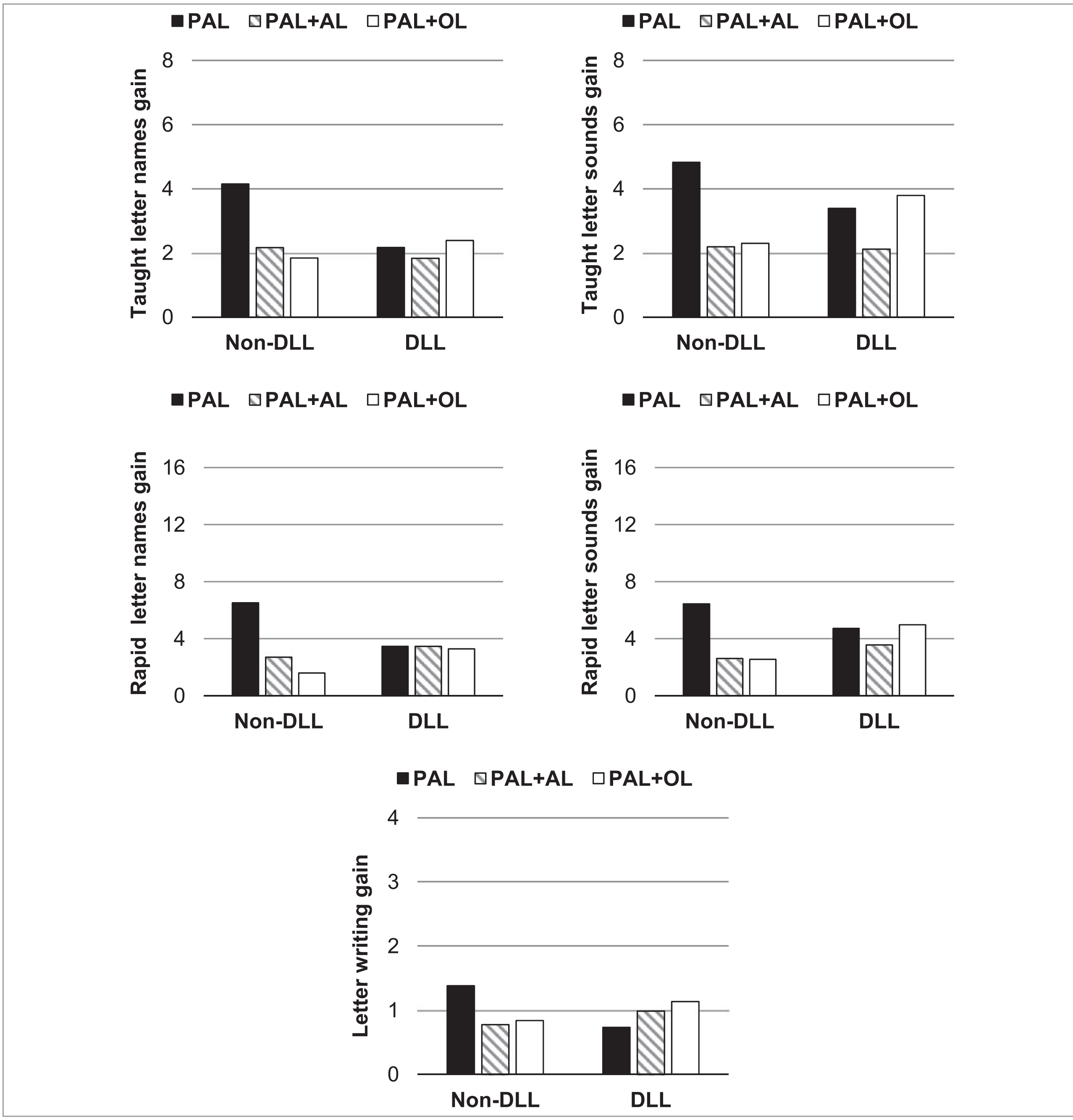
Measure	PAL Adj. *M*	PAL+AL Adj. *M*	PAL+OL Adj. *M*	PAL vs. PAL+AL						PAL vs. PAL+OL						PAL+AL vs. PAL+OL					
				Difference	*SE*	*t*	*df*	*p*	ES	Difference	*SE*	*t*	*df*	*p*	ES	Difference	*SE*	*t*	*df*	*p*	ES
DLL children																					
Taught letter names	2.17	1.83	2.39	0.34	0.74	0.46	89	.649	.08	−0.22	0.81	−0.27	92	.786	−.05	−0.56	0.82	−0.68	94	.500	−.12
Taught letter sounds	3.39	2.12	3.79	1.27	0.82	1.55	89	.126	.28	−0.40	0.90	−0.45	91	.656	−.08	−1.67	0.93	−1.81	93	.074	−.32
Rapid letter names	3.47	3.46	3.29	0.01	1.59	0.00	94	.997	.00	0.18	1.73	0.11	94	.916	.02	0.18	1.75	0.10	94	.919	.02
Rapid letter sounds	4.72	3.56	4.98	1.16	1.32	0.88	89	.383	.16	−0.26	1.44	−0.18	92	.859	−.03	−1.42	1.46	−0.97	94	.335	−.17
Letter writing	0.73	0.99	1.13	−0.26	0.39	−0.66	69	.511	−.12	−0.40	0.42	−0.96	76	.341	−.17	−0.15	0.43	−0.34	66	.732	−.06

Note. Adj. *M* = adjusted mean; AL = articulatory learning; *df* = degrees of freedom; DLL = dual-language learner; ES = approximate effect size computed as model-based adjusted mean difference divided by model-based adjusted approximate standard deviation; OL = orthographic learning; PAL = paired-associate learning; *SE* = standard error. PAL *n* = 19 non-DLL children, *n* = 13 DLL children; PAL+AL *n* = 19 non-DLL children, *n* = 13 DLL children; PAL+OL *n* = 21 non-DLL children, *n* = 9 DLL children. Statistically significant tests at the .05 level after Dunn–Šidák multiple-comparison *p*-value adjustment are in boldface.

Review of the alphabet outcomes for DLLs in Figure 1 shows that DLLs did quite well in the PAL-only condition compared with the other conditions on all alphabet outcomes; thus, the DLL pattern of no statistically significant differences between treatments is unlikely to be explained by decreased learning in the PAL condition. The lack of statistically significant differences among the three treatments for DLLs coupled with statistically significant pretest–posttest gains on letter name and letter sound identification—gains that can be reasonably attributed to instruction because gains for taught letter names and letter sounds was statistically significantly greater than those for untaught letters for both DLLs and non-DLLs—suggests that multisensory or multicomponent instruction drawing attention to (a) how the mouth articulates letter labels (names or sounds) or (b) the features of letter forms through writing may have benefited letter learning accuracy for DLLs. Further research testing this possibility is warranted. Alternatively, this pattern may indicate that DLL children's skill in English PAL is simply not yet as efficient as it is in non-DLLs. We did not have a counterfactual for the measures of letter identification speed and are therefore unable to rule out maturation of some other intervening variable as contributing to the pretest–posttest gains on these measures.

The level of letter sound and letter name learning merits attention. In this study, a post hoc comparison showed that letter sound learning was on a par with letter name learning (see Table 3). In addition, the multilevel models predicted the largest gain for letter sound identification accuracy (39%) compared with letter name identification accuracy (30%). The predicted gain for rapid naming of letter names and letter sounds was also higher for letter sound learning (17%) than letter name learning (13%). PAL-only instruction, compared with PAL+AL, had an overall effect size of 0.66. These gains compare very favorably to others in the literature and accrued from brief instruction. It is often assumed that learning alphabet letters is a low-level, constrained skill that is accomplished easily and perhaps informally by exposure to a print-rich environment. Recent evaluations of Head Start found an effect size of 0.25 for 4-year-old preschoolers on alphabet knowledge in a very large sample and no statistically significant effect for alphabet knowledge for 3-year-olds after a year in Head Start (U.S. Department of Health and Human Services, 2010). Similarly, the Preschool Curriculum Evaluation Research Consortium (2008) found that only one of the 15 curricula tested improved children's letter/word performance at all, in spite of being well-funded programs with professional development. Piasta and Wagner (2010a) reported an average effect size of Hedges's $g = 0.24$ across studies for letter sound learning.

FIGURE 1
Model-Predicted Means for Alphabet Outcomes, by Condition and DLL Status



Note. AL = articulatory learning; DLL = dual-language learner; OL = orthographic learning; PAL = paired-associate learning. Post hoc tests showed PAL > PAL+AL and PAL+OL on taught letter names, taught letter sounds, rapid letter names, and rapid letter sounds (not letter writing) for non-DLL children but not DLL children.

The comparable level of letter sound learning compared with letter name learning and the findings identifying the benefits of emphasizing PAL for both accuracy and speed of letter sound identification are particularly important given the evidence of the greater difficulty in learning letter sounds than letter names reported in previous studies (Huang, Tortorelli, & Invernizzi, 2014; Roberts et al., 2018). Participants in our study were younger and had lower entering language scores than those in most other studies. The present study began just two weeks after the start of preschool, yet we found effect sizes of 0.51 to 0.67.

For 3- and 4-year-old children just entering preschool, pretest English-language proficiency and letter

TABLE 5
Fixed-Effects Model Results for Pretest—Posttest Gains on Cognitive Learning Process Measures

	PAL					PAL+AL					PAL+OL				
Fixed effect	Coefficient	*SE*	*t*	*df*	*p*	Coefficient	*SE*	*t*	*df*	*p*	Coefficient	*SE*	*t*	*df*	*p*
Mean pretest–posttest gain	**5.39**	**0.48**	**11.16**	**8**	**<.001**	**7.95**	**0.63**	**12.63**	**5**	**<.001**	0.15	0.10	1.53	27	.137
Pre-IPT (*Z*)	0.12	0.49	0.24	90	.810	0.89	0.45	1.97	85	.053	0.06	0.09	0.64	86	.526
Respective pretest (*Z*)	**−3.60**	**0.45**	**−8.06**	**87**	**<.001**	**−3.56**	**0.43**	**−8.26**	**93**	**<.001**	**−0.70**	**0.09**	**−8.05**	**90**	**<.001**
Instruction: PAL (−1 = PAL+OL)	0.65	0.62	1.05	18	.307	**1.22**	**0.58**	**2.10**	**19**	**.049**	0.11	0.13	0.87	25	.391
Instruction: PAL+AL (−1 = PAL+OL)	−0.19	0.63	−0.30	18	.764	−0.70	0.59	−1.19	19	.250	0.08	0.13	0.61	27	.545
Order	0.04	0.45	0.09	22	.928	−0.02	0.43	−0.06	21	.955	**0.21**	**0.10**	**2.22**	**27**	**.035**
• PAL*Order	0.45	0.65	0.69	30	.495	−0.30	0.66	−0.46	26	.648	0.14	0.13	1.02	27	.315
• PAL+AL*Order	−0.50	0.66	−0.75	30	.459	−0.04	0.69	−0.06	28	.955	**−0.38**	**0.14**	**−2.81**	**28**	**.009**
DLL	−0.08	0.45	−0.18	89	.856	0.82	0.44	1.88	86	.064	−0.05	0.10	−0.53	92	.600
• DLL*PAL	−0.24	0.57	−0.41	88	.680	−0.29	0.54	−0.53	83	.600	0.09	0.12	0.70	89	.485
• DLL*PAL+AL	−0.93	0.59	−1.58	90	.118	−0.64	0.59	−1.09	94	.279	−0.13	0.12	−1.03	93	.304
• DLL*Order	−0.24	0.41	−0.59	93	.554	0.05	0.40	0.13	91	.896	0.08	0.09	0.87	94	.389
• DLL*PAL*Order	0.91	0.57	1.61	87	.112	0.09	0.56	0.17	84	.866	−0.24	0.12	−1.98	88	.051
• DLL*PAL+AL*Order	−0.06	0.59	−0.10	88	.920	0.36	0.57	0.63	83	.530	−0.11	0.12	−0.86	93	.391

Note. AL = articulatory learning; *df* = degrees of freedom; DLL = dual-language learner; OL = orthographic learning; PAL = paired-associate learning; pre-IPT = IDEA Pre-IPT Oral Language Proficiency Test (Stevens, 2010); *SE* = standard error. *N* = 94 preschool children within 27 small groups and eight teacher classrooms. Statistically significant tests at the .05 level after Dunn-Sidak multiple-comparison *p*-value adjustment are in boldface.

knowledge predicted pretest–posttest learning gains on four of the five alphabet measures. These factors were statistically significant even when instruction was designed to accommodate children's potential challenges for accessing and learning English alphabet content created by their status as novice learners of English. These accommodations included explicitly teaching vocabulary used in instruction, using only essential language in instruction, consistent modeling of learning tasks, using gestures and illustrations, routinizing instructional procedures, and verbal elicitation strategies (Abedi, Hofstetter, & Lord, 2004; August & Shanahan, 2006; Gersten & Geva, 2003; Icht & Mama, 2015; Roberts, 2003, 2005). These results indicate the importance of supporting rich oral language development for alphabetic learning. They also suggest the importance of further research to clarify potential developmental opportunities and constraints on when and how to provide print experiences to support alphabet learning prior to preschool entry at age 4.

Teaching Letter Names or Letter Sounds First

Overall, the order for teaching the names and sounds for the eight target letters did not influence alphabet learning outcomes. Previous studies have found that children learned letters that included the letter sound in the letter name better than those that did not, or that children with higher levels of preexisting letter name knowledge showed better learning of letter sounds. These findings have been interpreted to indicate that letter names may bootstrap letter sounds, thereby suggesting the potential advantage of being taught letter names prior to being taught letter sounds. Two training studies in which children were taught letter names or participated in activities drawing attention to written letter features (letter awareness) prior to letter sound instruction reported partial letter name facilitation to letter sounds only for those letters in which the letter sound could be heard at the beginning of the letter name (e.g., /d/ in *D* in English; Cardoso-Martins et al., 2011) or no letter name facilitation (Castles, Coltheart, Wilson, Valpied, & Wedgwood, 2009).

In the present study, in which prior letter name knowledge was experimentally induced in a within-subjects design, in which DLL and non-DLL children alike began with initial low levels of letter name and letter sound knowledge, and in which both letter name and letter sound facilitation of alphabet learning was tested, no evidence was found for letter name bootstrapping of letter sounds. Children began the study knowing on average less than one of the taught letter names or letter sounds. Perhaps some threshold level of letter name knowledge is needed before children can extract the conceptual insight into the relation between letter names and letter sounds, in which case bootstrapping from letter names to letter sounds may be detected. This idea could account for the difference in findings between this study and previous ones in which letter name knowledge was found to contribute to letter sound learning.

Of particular interest is the finding that in the PAL-only condition in which the greatest gain in alphabet knowledge was made, overall DLL and non-DLL children who first received letter sound instruction made statistically significantly larger gains on letter sound identification accuracy and speed. PAL-only instruction was particularly advantageous for learning letter sounds. We speculate that teaching letter names first may actually have interfered with and created confusion for subsequent, more difficult letter sound learning for novices who did not yet have sufficient understanding that letters can have a name and a sound to manage the sequential learning of letter names and letter sounds in the quickly paced instruction in this study.

CLP Measures, Instruction, and Learning

Children made statistically significant gains on measures of PAL, AL, and OL from pretest to posttest. Instruction designed to enlist and activate more of each of these CLPs did not lead to increased skill in the respective CLP. However, children who scored the lowest in PAL, OL, and AL at pretest experienced the most gain at posttest in the respective CLP resulting in a catching-up effect in the CLP targeted by their instruction. Individual differences in children's pretest PAL and AL CLPs (the two CLP measures with good reliability) correlated statistically significantly with about half of the alphabet learning gains for DLLs but not non-DLLs. These relations suggest that for children with limited proficiency in English and the language in which they are learning letter names and letter sounds, a stronger foundation prior to instruction in the CLPs relied on in instruction is a support for that learning. Finally, gains in CLPs did not correlate with alphabet learning or interact with instructional condition.

Instructional Implications

The findings support several recommendations for preschool English alphabet instruction. The multiple benefits of the instruction that included the most PAL recommend instruction of both letter names and letter sounds in which the pairing of verbal labels (names and sounds) and letter forms is emphasized. This instruction included explicit and simple routines, focused children's attention on pairing of letter names and letter sounds, and did not require acquiring and managing instructional materials beyond printed letters and game-like activities. We emphasize that effective instruction included multiple teacher models of the visual–verbal correspondences during teacher-guided participation of the entire small group, assistance when needed by the teacher providing correct responses, and self-regulated opportunities for children to individually enact diverse and engaging letter label and letter form pairing activities. The teacher-guided activities ensured correct responses and quick pairing of the letter label and letter form with the contiguity of the labels and forms believed to promote initial correct learning. This was the format for the introduction of the letter routine in each lesson. Examples of child-regulated activities include the animal game during which each child had their own set of materials, discriminated between only three letters to find, say the label for, and feed to an animal (whose spoken name began with the target letter) the correct letter form. Letter writing activities proceeded with children writing letters on individual whiteboards guided by their verbalization of writing strokes, such as "Down, around" for the letter *D*.

Another feature of the instruction was that the lesson routines were identical each day. Instruction was designed in this manner to assist children in anticipating and understanding the flow of each lesson and to create efficiency in the management of instructional materials to support greater allocation of cognitive resources to letter learning. The instruction utilized materials that are widely available in preschool settings, and the few special materials (e.g., animal game cards) can be easily created, thereby suggesting optimism that preschool teachers may implement PAL-focused instruction efficiently in preschool classrooms.

The interventions were implemented with small groups, a favored grouping constellation in preschool, and led to gains that were not statistically significantly different between DLLs and non-DLLs in classrooms serving both DLL and non-DLL children. The learning gains affirm the capability of DLL preschool children and children from families with low incomes to learn challenging content when instruction was explicit, incorporated CLPs relied on in alphabet learning, and was designed to ensure their success.

The finding that teaching letter sounds first benefited both accurate and rapid letter sound learning overall for both DLL and non-DLL children recommends teaching letter sounds first. This teaching implication is particularly important considering previous recommendations for teaching letter names first and the finding that with extensive PAL instruction, children learned the more difficult letter sounds to a similar level as they learned letter names. Implementation of the instruction, with practice in retrieving taught associations throughout the day to build memory, coupled with opportunities for children to apply their growing letter knowledge within a variety of meaningful activities (e.g., storybook reading time, pointing out children's names, calling attention to environmental print) would likely enhance learning.

Limitations

Several limitations should be considered. The instruction was brief both in terms of length of lessons and total instructional time (10 weeks), averaging approximately 20–24 minutes per letter. Patterns of performance may have been different with a more comprehensive alphabet program of longer duration that differentiated the amount of instruction on easier- and harder-to-learn letters (Jones, Clark, & Reutzel, 2013) and that began later in the year. The ability to investigate relations among CLPs and instruction were limited by challenges in measuring these processes and particularly so for our ability to evaluate OL. We did not find evidence of gain in individual differences in CLPs and alphabet learning, findings which would have added interpretive clarity to how the treatments worked. Floor effects on the posttest writing measure limited our evaluation of writing performance. Many children made limited gains; overall learning ranged from 16% to 40%. Continued effort to improve alphabet instruction to increase the rate of alphabet learning of all children is needed. Exploration of the potential value of multisensory instruction for DLL children is one direction that may be worthy of investigation. Finally, we were not able to evaluate the effect of the instruction and letter knowledge gains for later literacy competence.

Conclusion

Both non-DLL and DLL 3- and 4-year-old children attending public preschool programs experienced reliable gains in the explicit and letter-focused treatment conditions. Our results identify the prominent role of PAL in helping children on the road to mastery of the challenge inherent in learning letter names and letter sounds. The results also point to the benefit of teaching letter sounds before letter names when instructional routines provide ample learning opportunities to pair verbal labels and letter forms. Finally, the findings provide partial evidence of a relation between preexisting individual differences in language and CLPs hypothesized to underlie letter learning.

The sensitivity of children's alphabet learning to small variations in instructional content is highlighted in the findings on the advantages of PAL and order of teaching letter names or letter sounds. Effect sizes of

0.51 to 0.70 were found between closely matched treatments. The finding in favor of PAL-only instruction on letter identification accuracy and speed is amplified when considering that accuracy and speed in letter identification are unique predictors of decoding ability (Araújo, Reis, Petersson, & Faísca, 2015), and previous findings of difficulty in experimentally increasing letter naming speed (de Jong & Vrielink, 2004).

Further important nuance was revealed in the finding that language status moderated children's response to variation in instruction and the relation of CLPs to alphabet learning. These moderation effects highlight the importance of enhancing children's overall English proficiency and including sufficient numbers of DLLs and non-DLLs in preschool studies of early literacy to yield sufficient power to evaluate the effectiveness of instruction for DLL children. This research adds to the very limited knowledge base on effective methods for teaching young children English letter names and letter sounds (Piasta & Wagner, 2010b), particularly for children whose backgrounds may include alternative early language and literacy experiences than those more directly associated with accomplishing this necessary step in becoming literate in English.

NOTES

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Supporting Information

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- Appendix: Comparison of Instructional Conditions