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Introducing Grapheme-Phoneme Correspondences (GPCs): Exploring Rate and Complexity in Phonics Instruction for Kindergarteners with Limited Literacy Skills

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Abstract

Two experiments explored rates for introducing grapheme-phoneme correspondences (GPCs) and the types of correspondences taught for optimal alphabet and early literacy skills learning. In both studies, children entered with minimal alphabet knowledge and were randomly assigned within classrooms to one of two treatments delivered individually over five weeks. In Study 1, children grades K-1 were assigned to instruction in a set of either 10 (Slow rate, n = 33) or 15 (Fast rate, n = 32) single- and two-letter GPCs. Study 1 findings indicated that children who learned five added GPCs did not reduce learning of the common set of 10 learned GPCs for any measure (including letter names, sounds, letter sound writing, word reading, and spelling), and learning favored Fast items over Slow for letter sounds, letter sound writing, and word reading (median d = 0.30). In Study 2, kindergarteners were assigned to instruction in either single letters only (Single, n = 30) or mixed-size GPCs (Mixed, n = 31). Instruction included application of GPCs to decoding and spelling. Results showed that kindergarteners in the Mixed condition made significantly greater gains learning the four two-letter GPCs across measures (median d = 0.86), and no significant differences between groups on measures of the 11 one-letter GPCs common to both conditions. Findings add precision to understanding how rate and order of introducing GPCs influence children's initial alphabet learning. Further study of empirically validated methods of alphabet instruction may benefit in particular those children most at risk for acquiring this foundational knowledge.

Keywords: alphabet, decoding, grain size, grapheme-phoneme correspondences, kindergarten, phonics

Introducing grapheme-phoneme correspondences (GPCs): Exploring rate and complexity in phonics instruction for kindergarteners with limited literacy skills

Alphabetic and early word reading skills are more difficult to learn in the English orthography than in languages with more regular orthographies. The current study examines two features of instruction that influence how children are introduced to reading in English: the rate of introducing alphabet correspondences, and the type of grapheme-phoneme correspondences (GPCs) children first encounter. Children around the world learn to read words in many alphabetic languages. The challenge varies according to the orthographic depth of the language. In languages with transparent writing systems, the alphabet has a consistent and simple one-to-one match between letters and sounds (Frost, 1994). Children learn basic reading skills more easily in languages with regular orthographies, and children learning to read in English encounter one of the most inconsistent orthographies (Ziegler et al., 2010). In English, some letters, in particular vowels, have multiple ways they are pronounced in words, and some phonemes have multiple spellings, some are spelled with one letter, some with two or more letters. English readers must become flexible in both small (one letter) and larger-grain size mappings (Ziegler & Goswami, 2005).

Decoding is easier to learn in shallow and regular orthographies with consistent grapheme-phoneme correspondences (GPCs) (Seymour, Aro, & Erskine, 2003; Share, 2008), and is acquired within the first months of instruction in a highly regular orthography like Turkish (Oney & Durgunoglu, 1997). In comparisons of word reading skills at the end of grade 1 across languages, English-speaking children lag behind children learning to read in orthographically consistent languages (Ziegler & Goswami, 2006). In languages like Italian and Spanish with regular orthographies, most children attain word reading at the end of Grade 1 whereas children

in English-speaking countries require several years (Frith, Wimmer, & Landerl, 1998; Seymour et al., 2003). Grain size theory, while not uncontested (Schmalz, Robidoux, Castles, Coltheart, & Marinus, 2017), suggests that in in a deep orthography like English, readers learn to rely on larger sublexical units (Seymour et al., 2003; Ziegler & Goswami, 2006), and it draws attention to the different sizes of GPCs in English and how this knowledge is taught.

Regardless of orthographic depth, grain size, and regularity, children begin by learning the names and sounds of letters in the alphabet. The difficulty of this learning task is so often underappreciated that limited attention has been given to how to teach letter names and sounds most efficiently. The ability to process print requires reshaping innate basic perceptual abilities (Dehaene, 2009; Dehaene & Cohen, 2011), and this reshaping results from experience with print, and is fostered by explicitly teaching beginning readers to compare and to write letter forms.

Although some letter sounds in English are more difficult to learn than others (e.g., short vowels are more difficult than consonants), letters are often accorded equal amounts of time for instruction, often “a letter of the week.” Surprisingly, there are few guidelines on how many letters and at what pace they should be introduced. Introducing too many letters at a time imposes a heavy paired associate learning (PAL) demand that may confuse and frustrate young learners (Hulme, Goetz, Gooch, Adams, & Snowling, 2007). Introducing letters at too slow a rate delays learning to make discriminations among many similar letters, and limits decoding practice opportunities when children know only a small set of letters. Studies by Jones and colleagues (Jones, Clark, & Reutzel, 2013; Jones & Reutzel, 2012) suggest that introducing letters at a faster pace, with cycles of review, allows slower learners time to develop automatized letter retrieval for all letters, and allows faster learners to apply their letter knowledge sooner to decoding and spelling. In a recent “natural” experiment in Norway, Sunde, Furnes, and Lundetrae (2020)

examined the influence of teachers' pace of letter instruction in the first year of school on children's end of year letter knowledge, word reading, and spelling. A faster pace was associated with significantly better reading and spelling outcomes, in particular for the lowest performing students. However unlike English, children may learn GPCs at a faster rate in a relatively transparent language like Norwegian

Other questions concern the order of teaching letter-sound correspondences. Should higher frequency letters (a, m, s, t) be taught to accuracy before lower frequency letters (f, h, q, w), also allowing children to sooner use a limited set of high utility letters for spelling and decoding meaningful text? Are more regular letter-sound correspondences (m, t, b) better taught early than less regular correspondences (c, g)? Finally, English alphabet instruction typically first introduces all 26 single-letters, many with multiple sounds (e.g., vowels, c, g), although many English two-letter GPCs are highly frequent and more regular in sound (sh, ai, ee). Children learning to read in English eventually develop flexibility to process multiple grain size mappings (Goswami et al., 2003), either through print experience or direct tuition (Savage & Stuart, 1998). As Ziegler and Goswami (2005) observed, most instruction currently explicitly develops processing of small grain size units (single letters). A small body of research suggests that beginning reading instruction influences strategies that children use to read words (Sowden & Stevenson, 1994; McGeown, Johnston, & Medford, 2012; Walton & Walton, 2002).

In the highly opaque English orthography, are there advantages for phonics instruction that explicitly introduces children to grain size variations that characterize the language (e.g., Durgunoglu & Oney, 1999; Ziegler & Goswami, 2006)? Possible negative effects are that children would be confused by variable grain size. Arguments that support explicitly introducing beginning readers to this aspect of English words include the success of this approach in other

mixed-grain languages, including Albanian (Ellis et al., 2004) and Dutch (Schaars, Segers, & Verhoeven, 2017). Several British studies of the *Jolly Phonics Programme* support teaching kindergarten-age children both single-letter sound correspondences and high frequency digraphs (Bowyer-Crane et al., 2008; Stuart, 1999), and the British Early Reading Research Study found that instruction in 62 high frequency GPCs resulted in significantly higher literacy scores for lower-achieving beginning readers (Solity, Deavers, Kerfoot, Crane, & Cannon, 2000).

Matching Phonics Instruction to Language Features

Phonics approaches have not explicitly addressed instruction in English grain size variation. Brady's (2011) review of post-National Reading Panel (NRP) (2001) phonics research underscores the limited research on explicit phonics methods that attend to size variation in sublexical units. Instruction that supports the development of phonological "word form" has most prominently informed features of explicit and systematic phonics instruction, found by the NRP (2001) to benefit beginning readers who struggle with word reading skills (see Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001). Although often contentious debate has surrounded the relative merits of teaching small or large (i.e., rime) units for word reading, analysis of the programs for *beginning* readers indicates that knowledge of small unit grapheme-phoneme mappings is potentially more effective than knowledge of rimes in supporting reading of monosyllabic texts (Vousden, 2008). Rimes, however, are most useful once children have some letter knowledge, decoding skill, or orthographic knowledge.

Although grain size theory and more recent research on orthographic mapping (see Ehri, 2014) raise questions whether phonics approaches may better equip children to deal English language features, only analogy or rime unit approaches have been examined to date. In the review of NRP findings by Ehri, Nunes, Stahl, and Willows (2001), seven of the "larger unit"

studies were rime-analogy approaches. In their reexamination of NRP (2001) findings confirming the benefits of systematic phonics instruction, and in particular explicit alphabet instruction, Steubing, Barth, Cirino, Francis, and Fletcher (2008) called for continued experimentation to "move the field beyond simplistic instructional dichotomies" (p. 133). Large unit rime comparisons cannot inform how phonics instruction should be introduced to beginners. Clearly, with typical instruction in single letters only, most children learning to read English do eventually develop sensitivity to orthographic depth that allow them to read words like *leaf, rain, beach, path,* and *chick.* Children at risk -- including children with limited reading, print, and English language exposure and possibly children with less well developed executive function -- will likely take longer to become attuned to lexical constraints of English. Limited research suggests that struggling readers are less sensitive to sublexical information (Assink, Bos, & Kattenberg, 1996). Others have described benefits for teaching flexibility in word reading for older students (see Berninger & Nagy, 2008; Gaskins, 2008).

Phonics instruction in GPCs. Findings from training studies, most conducted with older children grades 1-3 who have received some initial phonics instruction, show that teaching a set of multiletter units generalizes to coding new multiletter units (Das-Smaal, Klapwijk & Van der Leij, 1996), and more accurate (Blachman et al., 2004; Conrad & Levy, 2011) and faster word reading (Van Daal, Reitsma, Van der Liej, 1994). Practice spelling with multiletter strings provides superior orthographic learning of these patterns compared to reading only (Shahar-Yames & Share, 2008). Savage and Stuart (1998) found that 6-year old children were able to transfer lexical knowledge of taught vowel digraphs to read novel words. Conrad and Levy (2011) found that children in grades 1 and 2 with slow naming speed taught to recognize common two- and three-letter patterns were able to read trained words more accurately and

faster, although generalization to new words seemed to require more pattern exposures to solidify representations. In a study by Christensen and Bowey (2005) second graders taught a grapheme-phoneme (GP) approach (including digraphs and consonant blends) showed transfer to more difficult tasks and reading transfer words, and benefits in reading accuracy and speed, spelling, and comprehension. Ehri, Satlow, and Gaskins (2009) found that struggling readers grades 1-3 taught to analyze the grapheme-phoneme correspondences within words had significantly higher reading and spelling than children taught a keyword analogy approach. O'Brien, Wolf, Miller, Lovett and Morris (2011) found that explicitly training children with reading disabilities (grades 1-3) to recognize two-letter spelling patterns (e.g., sh, ck) in varied sublexical, lexical, and text- level tasks resulted in improved orthographic recognition efficiency. Several British studies have documented benefits of a structured, synthetic phonics approach with attention to multiletter graphemes for disadvantaged younger 5-year olds (Bowyer-Crane et al., 2008; Solity et al., 2000; Stuart, 1999, 2006). Children as young as 5 years can remember and process two-letter units in reading and spelling words (Wright & Ehri, 2007). Training studies featured numerous repetitions to solidify representations and promote generalization (Conrad & Levy, 2011; Reitsma, 1983). In summary the research, primarily with children grades 1-3 supports that children taught larger units can transfer their knowledge to reading and spelling, with benefits that include accuracy and fluency.

Currently a subset of children show inadequate response to Tier 2 and 3 early reading interventions (Denton et al., 2013; Nelson, Benner, & Gonzalez, 2003; Wanzek et al., 2013). Widely used U.S. kindergarten phonics curricula that emphasize the phonological consistency of words are effective for most children. This emphasis may mislead at-risk beginning readers less prepared to be successful problem solvers in English orthography (Perfetti, 2007; Tunmer &

Chapman, 2011) and those with limited print experience that provides insights into typical English spelling patterns. Many kindergarteners enter school with limited alphabet knowledge and print experience (Molfese et al., 2006; West, 2000) and demonstrate slow rates of alphabet acquisition (Authors, 2018). The scope and sequence for most alphabet instruction has not been informed by consideration of orthographic depth, the complexity and predictability of GPCs (Schmalz, Marinus, Coltheart, & Castles, 2015), although greater precision in design may improve rates of learning this necessary skill.

Our goal in two exploratory studies was to examine whether introducing lower skilled children (kindergarten and first grade) to highly frequent and consistent mixed-grain size GPCs transfers to initial decoding and spelling. Because most previous research phonics methods that explicitly teach GPC phonics was conducted with older children, we first established a rate for introducing GPCs that would not place excessive cognitive demands on beginning learners, and would allow us to measure learning within a brief 5-week intervention. In Study 1, we compared two rates for introducing letter-sound correspondences to a sample of lower-skilled kindergarten and first-grade children. In Study 2, we used the best teaching rate and compared instruction in single- or mixed-grain size correspondences with lower-skilled kindergarteners. In both studies, we examined whether explicit instruction showed transfer to growth in children's early skills.

General Procedures

A team of 11 research assistants were hired as instructors, all with previous training and experience in schools, including former classroom teachers and paraeducators. Instructors were provided a half-day training before each study in which researchers modeled lesson delivery, corrections, pacing, and RAs were observed practicing lesson delivery and provided feedback. Training emphasized instructional delivery, including explicitly modeling new content and skills

such as new letter sounds, and difficult skills like blending or segmenting. Researchers were on site daily, and met with the instructors for informal lunch meetings and individual coaching.

A team of six research assistants were hired as assessors and included former teachers, a school psychologist, and a school principal. Assessors were trained in a half-day session prior to each study in which assessments were demonstrated by researchers, and research assistants paired up to practice measures with researcher feedback. Research staff included a project coordinator with over 15 years' experience overseeing school-based early reading interventions, and an assessment coordinator with 20 years' experience, including clinical testing and training assessors. In each study researchers observed each student-tutor pair twice during the intervention. At each observation the researcher completed a standardized observation protocol that included all instructional components and these were used to provide feedback to tutors.

Study 1: Rate of Instruction

Methods

Participants

Participants for from two elementary schools in the Northwest U.S., one all-kindergarten building and one K-5 elementary. Kindergarteners were identified based on their fall school screens for alphabet knowledge, all knowing less than three letter names or sounds, and subsequent teacher confirmation. First-grade students were identified based on their scoring below 50th percentile on their spring kindergarten STAR Early Literacy Assessment (Renaissance Learning), with first-grade teacher confirmation of current at-risk status. A parent letter (translated into three major languages) was sent home with all identified students; teachers informed us of parents who chose to "opt out."

The initial sample included *N* = 69 consented children from 27 classrooms who were randomly assigned, within classroom and English learner (EL) status, to one of two experimental conditions (Fast pace *n* = 35, or Slow pace, *n* = 34). (EL status was determined by whether a language other than English was spoken at home.) After attrition due to pretest absences, the final sample included *N* = 65 children from 25 classrooms: 32 in the Fast condition and 33 in the Slow. Of these children, 34 (52%) were kindergarteners, 31 (48%) were EL students, and 46 (71%) were children of color. There were no significant differences between conditions on grade level, EL status, child of color status, age, or any pretest; by a fluke, there were more females in the Fast condition (*n* = 18, 56%) compared to Slow (*n* = 9, 27%). Tutor assignment was based on school scheduling convenience. There were 11 tutors: six at the school with participating kindergarteners, and five at the school with participating first graders; each tutor served five to seven children daily, with approximately half in each of the two conditions.

Materials and Procedures

Two sets of lessons (Fast, Slow) were prepared to examine and fine tune an optimal rate of instruction in the target orthographic spelling patterns. The Fast lessons introduced students to 10 single-letter and 5 two-letter spelling patterns during the 5-week intervention. The Slow lesson introduced students to seven single-letter and three two-letter correspondences. The scope and sequences were informed by our earlier work on phonics instruction for lower performing K-1 students. The contrast between the rates was constrained by the brief period of intervention, and even in the slower lessons we needed to teach a minimum number of correspondences in order to measure learning. The goal was to detect trends for a rate advantage, and to use that rate for subsequent intervention comparisons. In Study 1 we also examined differences in response to each rate of instruction for kindergarten and for first-grade students, and again used that

information to inform recruitment for Study 2. Instruction in both studies was provided in 20-minute sessions, 4 days a week, with the instructor working one-to-one with each student.

Children were taught a common set of 10 letter correspondences in both conditions (a, m, ea, s, t, oo, d, o, sh, r) and children in the Fast condition were taught an additional five letter correspondences (p, n, ai, g, ck). In the Fast condition, two-four new correspondences were introduced each week. In the Slow condition, one-three new correspondences were introduced each week. All lessons were scripted, with the tutor instruction in a column on the right side of a page, and the letter and word items for student practice in large print on the left side of the page. Children in both conditions learned to immediately apply knowledge of taught correspondences to decoding and spelling tasks. Across treatment paces, activities for each lesson included:

Say write the sounds. The instructor introduced and modeled new letter sounds, and the student repeated each sound. The student then pointed to each letter in an array of new and previously taught letters and said each sound. Letters that were newly introduced were always featured four times in the array, with cumulative review of previously taught letters. The instructor then dictated new sounds for the student to write.

Matching spoken and printed initial sounds. The instructor asked the student to point to the letter in the array that corresponded to the first sound in a spoken word (e.g., “Point to the letter that says /t/ as in Tom”).

Segmenting. The instructor modeled segmenting a word, and then dictated a word for the student to segment using printed segmenting boxes. Segmenting began with initial sound segmenting, and progressed to three-phoneme segmenting.

Modeled blending. The instructor modeled exaggerated blending, stretching out the sounds in a cvc word, then saying the word fast. Then the instructor slowly spoke the blended sounds in a word, and asked the student to say the word fast.

Word reading. The instructor modeled blending words composed of taught letters, and the student repeated blending and reading the word. Instructors spent the most lesson time on this activity, with as much modeling, unison blending, and scaffolding as needed.

Spelling. A sequence of steps was used for spelling. First the instructor dictated the word and the student segmented the word into sounds, pointing to the squares in two- or three-part segmenting box. Next the student wrote the letters that correspond to each sound in a word, using sheet of phoneme-grapheme mapping paper.

Speeded letter retrieval. The student alternated practice pointing to the taught letters dictated by the instructor, and saying the letter sound the instructor pointed to. Letters were arranged in rows on a sheet of paper, and as students developed accuracy, the student was encouraged to point or to say the sounds more quickly.

Measures

Receptive vocabulary was measured at pretest only with the *Peabody Picture Vocabulary Test* (PPVT-4) (Dunn & Dunn, 2006). Coefficient alpha reported in the test manual is .97 for 5-year-olds. Sample-based internal consistency (KR20) was .98 for both studies.

Experimenter Measures. For each of the five experimenter measures, all letters taught in both groups were tested at pretest and posttest. The order in which the taught letter and word items (featuring taught letters) appeared in each test was randomized. Letter and word items matched the taught letter content for each study. All test items were scored 1 or 0. For Study 1 scores on experimenter measures were computed for total common items correct (10 items) and

for total Fast only condition items taught (5 items). For brevity, for each set of items in both studies, percent correct was calculated at pretest and posttest, as was pretest-posttest change.

***Taught letter names and sounds*.** For each test the tester presented a printed sheet of 20 taught letters randomly arrayed in four rows of five items per row. Students first completed two practice items with untaught letters. The tester directed the student to point and say the name (or sound) for each item, with 3 secs allowed for each item. If the student said the sound for the name (or vice versa), the tester prompted, "Yes, that's the sound, what is the name." The tester recorded 1 or 0 for each response and the total time to name or say the sound for the items. For letter names, sample internal consistencies (KR-20) were .97 and .87 for common items at pretest and posttest, respectively; for Fast only items, reliabilities were .93 and .77. For letter sounds, sample internal consistencies were .94 and .82 for common items (10 items) at pretest and posttest, respectively; for Fast only items (5 items), reliabilities were .87 and .84.

***Taught letter sound writing*.** For each of the taught 20 letters, the tester dictated the taught sound for the student to write. The tester reminded the student that sometimes one letter makes the sound, sometimes two letters make the sound. Two practice items with untaught letters (z and wh) were first administered. The tester dictated each sound, and repeated the sound once, allowing 5 sec for each letter. If the student wrote only one letter of a two-letter sound, the tester prompted "This is a two-letter sound, write both letters that make this sound." If the student wrote two letters for a one-letter sound, the tester prompted "This is a one letter sound." Sample internal consistencies were .92 and .87 for common items at pretest and posttest, respectively; for Fast only items, reliabilities were .88 and .83.

***Word reading*.** Students were asked to read 20 cvc words constructed with taught letters that appeared in initial, medial, and final word positions. The tester first administered a practice

item, demonstrating pointing to the word, blending, and reading the word fast as students learned to do in the intervention. The words were presented on a card in two columns and the tester directed the student to point to each word and read down each column, allowing 5 sec per word. If the student correctly said each of the sounds within 5 sec but did not blend the sounds, the tester prompted once to "Say it fast" and allowed 3 sec for the student to read the word. Sample internal consistencies were .91 and .95 for common items at pretest and posttest, respectively; for Fast only items, reliabilities were .84 and .86.

Spelling. A set of 20 cvc words were used to test spelling with taught letters that appeared in initial, medial, and final word positions. The tester dictated each word, repeated the word once upon request, and allowed 5 sec/word. Sample reliabilities were .94 and .96 for common items at pretest and posttest, respectively; for Fast items, reliabilities were .77 and .89.

Fidelity. During the first week of treatment implementation, fidelity reliability among three observers (first author and two assistants) was established by simultaneously observing seven tutor-student pairs across the two school sites (three implementing Slow and four implementing Fast). The percent of correct implementation across 16 curricular elements and four instructional delivery elements was tabulated, and correlations among the three pairs of raters ranged from $r = .95$ to >.99 on curricular elements; correlations were perfect on delivery elements ($r = 1$). Thereafter, each tutor-student pair in the study was observed between one and four times, for a total of 137 observations across the 65 children (averaging two observations per student). There were no significant differences or trends found for either type of fidelity percent correct (all Satterthwaite adjusted *t*-test *p*-values > .27). Across conditions, curricular implementation averaged 97.18% correct ($SD = 5.49\%$), and instructional delivery averaged 93.05% ($SD = 12.10\%$). Given the ceiling effect observed (which was also expected given the

nature of the study) and given that there were no significant differences between conditions, we did not use either fidelity measure in our outcome models.

Analysis Plan

Multilevel modeling was used to analyze data while accounting for dependencies in child-level data due to classroom membership. Preliminary analyses showed that intraclass correlations among pretests and posttests due to tutors and classrooms were similar. Given this comparability, and given also that tutors were delivering heavily scripted lessons coupled with the fact that classrooms were likely to vary in literacy instruction time and curricula, we treated classroom membership as Level 2 instead of tutors (we also note there is insufficient data for cross-classified modeling). Intercept-only models showed that the median intraclass correlation (ICC) for classrooms across all experimenter measures was .58 at pretest, .45 at posttest, and .13 for pre-post change. As such, classroom membership explained an average of 58% of student pretest scores, 45% of posttest scores, and 13% of pre-post change.

Our final analyses modeled pre-post change on common and treatment-specific items as a function of experimental condition, grade level, EL status, and pretest as well as all 2-way interactions with treatment condition, with students (Level 1, $n = 65$) nested within classrooms (Level 2, $n = 25$). As mentioned earlier, although there was disproportionality in gender across conditions (more females in the Fast condition), gender was not correlated with pre-post change, and including gender in our analytical models did not change substantive results. As such, gender was not considered further. For ease of results interpretation, we effect-coded binary predictors (Fast = +1, Slow = -1; Grade K = +1 and Grade 1 = -1; EL = +1, non-EL = -1), and standardized pretest into *Z*-scores. Grade level was a classroom-level predictor and all remaining predictors were student-level. Models were estimated using full information maximum likelihood in *HLM7*.

Results

Descriptive statistics (unadjusted for classroom membership) are shown in Table 1 for the combined grade levels (see Tables S1 and S2 in the online supplement for descriptives for each grade level by EL status, as well as Tables S3 and S4 for zero-order correlations among variables included in analyses for Common and Fast only items, respectively).

Common Item Assessments. For assessments involving items common to both Fast and Slow conditions, model results (Table 2) showed that students across both conditions made significant mean pretest-posttest gains on all outcomes (e.g., on letter names, students increased by 22%, and on letter sounds, by 42%). Kindergarteners, irrespective of treatment condition, made significantly less gains on word reading and spelling (18% lower than the average gain from pretest to posttest). In addition, pretest significantly negatively predicted gains on letter sound items (children who started out higher were predicted to have less learning). There were no significant differences between treatments, nor were there any interactions.

Fast Only Assessments. Results for items that only appeared in the Fast treatment (Table 3) were similar to the common item assessments in that all children, on average, showed significant increases from pretest to posttest. We further found that kindergarteners were generally predicted to make less gains compared to first graders, and that higher pretests again indicated less pre-post gains. However, in contrast to results for common items, there was a significant advantage for the Fast condition over Slow on three measures: children in the Fast condition were predicted to have 15% better learning on letter sounds compared to average learning, 12% better learning on letter sound writing, and 5% better learning on word reading. There were also two interactions detected between condition and pretest – on letter sounds and

letter sound writing. Predicted values (shown online, Figure S1) showed that the Fast treatment was more beneficial for kindergarteners compared to first graders on these measures.

Study 2: Influence of Grain Size

Participants

Drawing upon results from Study 1 showing that the Fast pace produced more learning and was most beneficial for kindergarteners on letter sound learning, for Study 2 we narrowed our sample to kindergarten students only (from the same two schools as Study 1). Students were screened eligible in December if they knew fewer than 11 letter sounds, and no child who participated in Study 1 was included in Study 2. The sample initially included 64 students from 24 classrooms who were randomly assigned, within classroom and English Learner (EL) status, to one of two treatments (32 in each). After attrition due to testing absences, the final sample included 61 children from 22 classrooms: 30 in Single and 31 in Mixed. Of the total, 34 (56%) were EL students, and 31 (51%) were children of color. There were no significant differences between conditions on EL status, child of color status, age, or pretest; however, there were again more females in the Single condition (n = 19, 63%) compared to Mixed (n = 11, 36%).

Students received five weeks of one-to-one instruction from a tutor assigned to them; tutor assignment was based on school scheduling. There were nine tutors: three at one school and six at the other; each tutor served six to eight children, with approximately half in each condition.

Materials and Procedures

Two sets of lessons were used. Single lessons featured one-letter correspondences only, and Mixed lessons featured a mix of single and two-letter correspondences. In each condition, 15 correspondences were taught over 5 weeks, the rate found most effective in the Study 1. The following correspondences were taught in the Single condition: a, m, s, t, c, d, i, n, l, o, g, r, p, h,

u. The Mixed condition featured 11 single letter and 4 two-letter correspondences: a, m, s, t, c, ee, d, oo, ai, p, o, sh, i, n, l. The four letters g, r, h, and u were taught only in the Single condition, and letters ee, oo, ai, and sh were taught only in the Mixed condition. The two-letter correspondences taught in the mixed condition were chosen for their high frequency in early reading materials, and the most frequent sound for each pair was taught (Fry, 2010). Lessons also utilized plastic letter tiles, laminated Elkonin segmenting boxes, and word cards for sorting tasks. Letter tiles were used for spelling because children's writing skills hindered their performance on writing tasks. Again, all lessons were scripted, with the tutor instruction in a column on the right side of a page, and the letter and word items for student practice in large print on the left side of the page. Teaching activities for each lesson, which were the same for each condition, were:

Say write the sounds. This was the same as in the Study 1.

Matching spoken and printed initial sounds. This was the same as in the Study 1.

Identifying letters in words. Using an array of printed words the instructor pointed to one of the newly taught letters in a word, asked the student to say the sound and read the word. The instructor pointed to taught letters in different positions in the words.

Word sort. Prior to each lesson, instructors made up index cards printed with six-eight decodable words based on previously taught letters. The student first read each word, with scaffolding from the instruction to blend the sounds and read the words. The student then sorted the words by initial sounds. As students learned to sort by initial sounds, the instructor adapted the activity to have students sort by final and middle sounds.

Find letter sounds in words. Presenting each word card, the instructor spoke one of the taught sounds and asked the student to point to the letter in the word and read the word.

Segmenting. Using letter tiles and a laminated set of segmenting boxes, the instructor dictated four-six words composed of taught letters, having the student segment the word into phonemes, and to place the matching letters in each box, then read the word.

Spelling. Using the letter tiles and the segmenting boxes, the instructor dictated a word, the student repeated the word, and the student spelled the word, placing the letter tiles in the correct boxes. Student read all spelled words.

Sentence reading. The instructor and student read together a two-three sentence story composed of mostly decodable words. The student and instructor read each sentence two-three times to practice fluent reading in context.

Speeded letter retrieval. Using an array of taught letters, the instructor said one of the taught sounds and asked the student to quickly point to the letter that matched the sound. Then the student pointed to each letter in the array and said the sound.

Identify the sound in a spoken word. Using the letter tiles and segmenting boxes, the instructor pointed to a letter tile (e.g., a), spoke a word (e.g., tap), and asked the student to place the tile in correct box (the middle box) where the sound is heard.

Discriminating printed words. With both student and instructor pointing, the instructor read aloud a sentence with a blank for a missing word. When the instructor came to the blank she spoke the missing word. The missing word appeared in an array of three words printed below the sentence, with minimal spelling differences between the words (e.g., correct word is *mat*, and *mat* appears with *mot* and *sat*). The student pointed to the correct word that goes in the blank, and then the instructor and student reread the sentence in unison, with the student pointing to the correct word when it was spoken.

Measures

The same measures and assessment procedures used in Study 1 were used for Study 2. All test items were scored 1 or 0. However for the experimenter measures, in Study 2 there were three sets of items: those common to both conditions (11 items for letter names, sounds, and sound writing; 12 for word reading and spelling), those taught in the Mixed condition only (4 items), and those taught in the Single condition only (4 items). For brevity, percent correct was again calculated at pretest and posttest, and pre-post change.

Taught letter names (19 items) had sample-based internal consistencies (KR-20) of .79 and .74 for common items (11 items) at pretest and posttest, respectively. For Mixed only items (4 items), reliabilities were .72 at pretest and .74 at posttest, and for Single only items (4 items), reliabilities were .67 at both pretest and posttest.

Taught letter sounds (19 items) had reliabilities of .88 and .82 for common items (11 items) at pretest and posttest, respectively. For Mixed only items (4 items), reliability was close to zero at pretest (due to floor effect) and .88 at posttest; for Single only items (4 items), reliabilities were .72 and .77 at pretest and posttest, respectively.

Taught letter sound writing (19 items) had reliabilities of .88 and .83 for common items (11 items) at pretest and posttest, respectively. For Mixed only items (4 items), reliability was close to zero at pretest (floor effect) and .73 at posttest; for Single only items (4 items), reliabilities were .72 and .69 at pretest and posttest, respectively.

Word reading (20 items) had reliabilities of .92 and .90 for common items (12 items) at pretest and posttest, respectively. For Mixed only items (4 items), reliability was again close to zero at pretest due to floor effect and .66 at posttest; for Single only items (4 items), reliabilities were .69 and .80 at pretest and posttest, respectively.

Spelling (20 items) had reliabilities of .86 and .91 for common items (12 items) at pretest and posttest, respectively. For Mixed only items (4 items), reliability at pretest was close to zero at both pretest and posttest; for Single only items (4 items), reliabilities were .59 and .78 at pretest and posttest, respectively.

Fidelity. During the first week of treatment implementation, fidelity reliability among three observers (first author and two assistants) was established by simultaneously observing 14 tutor-student pairs across the two school sites (six implementing Single and eight implementing Mixed). The percent of correct implementation across 13 curricular elements and four instructional delivery elements was tabulated, and correlations among the three pairs of raters ranged from r = .93 to >.99 on curricular elements and from r = .75 to >.98 on delivery elements. Thereafter, each tutor-student pair in the study was observed between one and four times, for a total of 137 observations across the 60 children (averaging two observations per student). There were no significant differences or trends found for either type of fidelity percent correct (all Satterthwaite adjusted t-test p-values > .45). Across conditions, curricular implementation averaged 97.62% correct (SD = 5.15%), and instructional delivery averaged 95.60% (SD = 12.62%). Again, given the ceiling effect and the nature of the study, and given that there were no significant differences between conditions, we did not use either fidelity measure in our outcome models.

Analysis Plan

Our Study 2 analyses were the same as Study 1, except that we only had one grade level (kindergartners). Intercept-only models showed that the median intraclass correlation (ICC) for classrooms across all measures was .02 at pretest, .01 at posttest, and .02 for pre-post change (classroom membership explained approximately 2% of scores). As with Study 1, although there

was gender disproportion across groups, gender was not significantly related to outcomes, and its inclusion did not alter our substantive findings; as such, gender was not used as a predictor.

Results

Descriptive statistics are shown in Table 4; online we provide more detailed descriptives by EL status and for gains (Table S5) as well as zero-order correlations (Tables S6-S8).

Common Item Assessments. For assessments involving items that were common to both Mixed and Single conditions, model results (Table 5) showed that students across both conditions made significant mean pretest-posttest gains on all outcomes (for example, on letter names, the children increased by 14% and on letter sounds, by 44%). In addition, pretest significantly negatively predicted gains letter sound items (children who started out relatively higher were predicted to have less learning, all else held constant). Although there were no significant treatment main effects, there were two treatment-by-pretest interactions – for word reading and spelling. Predicted values (online Figure S2) showed that children with lower pretest levels benefited from Single instruction more than Mixed in terms of word reading and spelling gains; for children with higher pretest levels, Mixed instruction had better word reading gains.

Mixed Only Assessments. For items that only appeared in the Mixed treatment (Table 6), children again made significant gains from pretest to posttest, irrespective of group. More importantly, the Mixed instruction group had significantly better gains than average growth, particularly for mixed letter sounds and mixed letter sound writing (35% and 25% more than average gains of 37% and 33%, respectively). This said, results were qualified by two treatment interactions with EL status: one for letter names and one for spelling. Predicted values (online Figure S3) showed that Mixed instruction only benefited Non-EL children on these two outcomes; for EL children there was little difference between treatment instruction types.

Single Only Assessments. Last but not least, model results for items that only appeared in the Single instruction treatment are shown in Table 7. Similar to the Common and Mixed only assessments, there was significant mean pretest-posttest growth across all Single only assessments. As can also be seen, there was only one benefit of Single instruction on the Single assessments, and this was for letter sounds (children in the Mixed condition made 11% lower gains than average growth, and 22% lower gains compared to Single instruction). This said, there were a few treatment interactions. Model-implied values (online Figure S4) showed that Single instruction was better than Mixed on single letter skills growth for lower-skilled children, and that Single instruction was beneficial for ELs on single letter sounds and letter sound writing.

Discussion

In two exploratory studies we examined features of phonics instruction in the mixed grain size English orthography. The first question concerned a considerate rate for introducing grapheme-phoneme correspondences (GPCs) to beginning readers. The second question concerned whether beginning readers can learn both single-letter and multi-letter GPCs and transfer knowledge of these correspondences to decoding and spelling. In Study 1 we found that lower-skilled kindergarten and first graders, including English learners (ELs), best learned a set of mixed grain size letter-sound correspondences introduced at the Faster rate of three correspondences per week. Not surprisingly, kindergarteners were less able to transfer GPC training to word reading and spelling than first graders. In sum, Study 1 findings established a brisk rate for learning GPCs that did not overwhelm the novice alphabet learners who entered with minimal alphabet knowledge.

Study 2, which began in January of the school year, used a teaching rate, informed by Study 1, of three letters a week, and compared learning for a set of 15 single-letter only

correspondences, and a set of 15 multi-letter correspondences. Children successfully learned both the single-letter and two-letter correspondences. Advantages for Mixed grain size instruction were found, not surprisingly, for letter names and letter sounds, and for word-level experimenter measures that included all letters taught in the Mixed condition.

Findings suggest that children who received Mixed instruction were better able to transfer their GPC instruction to decoding, word reading, and spelling tasks. Many two-letter GPCs may be more easily learned than one-letter correspondences because they are more visually distinctive, and have continuous sounds (e.g., ee, oo, sh, ai) that are less fleeting than many single letter taught sounds (e.g., d, p, t, i), and that are also more easily blended. On the word reading posttest, children in the Mixed group read 41% of words with 2-letter correspondences correctly (aid, tool, see, shot) compared to 30% of words with single letters only.

Limitations

One limitation for our study is the floor effect observed on a handful of measures for Study 2, for our treatment-specific assessments in particular (not common items). It is possible that more reliable measures would have detected stronger treatment differences. How children were identified for participation is another limitation for generalizing findings. Kindergarten children in Study 1 (which began in the fall) were identified with a letter knowledge screen administered by kindergarten school staff, but first graders were identified using their spring kindergarten district assessment from earlier in the year. The sample for Study 2 (kindergarteners only) was identified by a letter knowledge screen administered by school staff in November, after children had some time to respond to classroom literacy instruction. As such, the risk status for the winter sample is more established. Children in both studies also received classroom literacy and alphabet instruction, which we were not able to observe or document, but

nevertheless likely plays some role in student outcomes. Indeed, the intraclass correlations showed that, in Study 1, which included both kindergarteners and first graders, classroom membership explained large portions of variance in student literacy skills; in contrast, in Study 2 (kindergarteners only), classroom explained very little variance in student outcomes. Last but not least, there were unplanned interruptions during Study 2 that may have affected learning, Study 2 began in January, and was interrupted after the first week of instruction by an eight-day snow school closure. Students returned to school for one day of instruction, followed by a 1-week winter break. The last 12 days of instruction resumed afterward.

Implications and Directions for Future Research

Beginning reading instruction in the U.S. has been informed by an expanding research base, guided by the phonological deficit hypothesis, yet certain aspects of instruction remain influenced by tradition and "beliefs and attitudes about how children learn" (Seidenberg, 2013, p. 341), including how alphabet knowledge is introduced. There is limited sharing of effective practices for introducing alphabets in varied orthographies Typical explicit phonics instruction for beginning readers in the U.S. first introduces students to single-letter correspondences and applied practice in phonological decoding with these taught correspondences. For at-risk beginning readers practice is often provided in decodable texts, and with controlled vocabulary. This scaffolded practice appears beneficial in early stages of reading development (Juel & Roper-Schneider, 1985), but also delays children's access to more natural and engaging text and motivating experience that rewards reading and writing. Although grain size theory suggests that GPC size would influence student learning, in particular for these youngest learners, children did not have difficulty learning the 2-letter units.

How might findings influence the design and content of explicit phonics instruction, in particular for children who enter kindergarten with the most limited literacy knowledge? Study 1 findings suggest an optimal rate for introducing GPCs. Children entering kindergarten knowing fewer than three letter names or sounds were able to learn most of the taught letter sounds. Study 2 findings inform decisions about the content of instruction, which GPCs should we teach. Results suggest that children can be introduced to a wider and more representative range of English GPCs. We explored instruction in a small set of high frequency GPCs that could be used for decoding and spelling. There may be several benefits to introducing high frequency two-letter GPCs. First, the words used in decodable storybooks for decoding practice can be more varied and more natural and engaging. For example, letter sound learning for students in Mixed instruction was similar or higher for sh, oo, ee, and ai than for a, i, s, and o, and correspondences sh, oo, and ai can be used to generate more K-1 level words than single letters j, q, x, y, and z.

Our findings raise questions for future research. Many children who will be at risk for reading difficulties struggle to learn in current methods of alphabet instruction, and earlier studies suggest that instruction with a faster rate, and using multiletter units most benefits lower performing children (Jones et al., 2012, 2013; Solity et al., 2000). Greater attention to how and which GPCs are taught should inform the design of explicit phonics-based methods of reading instruction. Future study should examine the benefits of teaching high- to low-frequency GPCs, including single and multi-letter units, to examine ease of learning, transfer to early decoding and spelling, and effects on self-teaching and orthographic word reading. For example, distinct and continuous GPCs like sh and oo appeared easier to remember (more distinct shapes) and to assemble in a sound sequence to blend, a challenging skill for many children. A longer study could test whether certain GPCs can be more easily applied in decoding and spelling tasks. A

related question is whether learning multi-size letter units influences reading-related cognitive flexibility, drawn upon in both word reading (Cole, Duncan, & Blaye, 2014), and to a greater extent, in reading comprehension (Cartwright, 2002; Cartwright, Marshall, Dandy, & Isaac, 2010)? Engaging teaching activities might be designed to develop flexibility in processing a more complex set of GPCs. These questions require longer interventions that introduce a larger number of correspondences, giving more time for practice and transfer to authentic decoding and spelling tasks, and follow up to end-of-year literacy outcomes. Future research would determine if this early orthographic orientation benefits specific groups of children. Effective phonics interventions successfully teach young children how, in the deep English orthography, sounds are represented in words, many sounds with one letter, and some with two or more letters. Findings from these brief studies, and earlier research, suggest that the rate of introducing letters, and the size of letter units that are first introduced influence children's GPC learning, and suggest reexamining how these correspondences can be taught more effectively, in particular for children most at risk to struggle with this essential learning.

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Table 1

Study 1 Descriptive Statistics

Measures	Fast (*n* = 32)		Slow (*n* = 33)		F v. S
	M	*(SD)*	*M*	*(SD)*	*d*
Pretest					
Age	6.10	(0.61)	6.07	(0.56)	0.07
Receptive Vocab	76.94	(32.87)	79.52	(24.01)	-0.09
% Correct Common Items					
Letter Names	0.41	(0.42)	0.47	(0.46)	-0.12
Letter Sounds	0.33	(0.38)	0.35	(0.35)	-0.04
Letter Sound Writing	0.27	(0.33)	0.33	(0.34)	-0.17
Word Reading	0.21	(0.30)	0.21	(0.29)	-0.01
Spelling	0.23	(0.35)	0.22	(0.31)	0.05
% Correct Fast Only					
Letter Names	0.34	(0.42)	0.41	(0.44)	-0.16
Letter Sounds	0.31	(0.36)	0.31	(0.35)	-0.01
Letter Sound Writing	0.25	(0.34)	0.27	(0.35)	-0.07
Word Reading	0.16	(0.26)	0.22	(0.33)	-0.21
Spelling	0.17	(0.26)	0.17	(0.26)	0.00
Posttest					
% Correct Common Items					
Letter Names	0.68	(0.27)	0.65	(0.33)	0.10
Letter Sounds	0.78	(0.26)	0.76	(0.26)	0.08
Letter Sound Writing	0.73	(0.28)	0.70	(0.33)	0.10
Word Reading	0.40	(0.42)	0.41	(0.41)	-0.02
Spelling	0.33	(0.40)	0.40	(0.42)	-0.17
% Correct Fast Only					
Letter Names	0.58	(0.34)	0.54	(0.37)	0.12
Letter Sounds	0.29	(0.28)	0.28	(0.23)	0.06
Letter Sound Writing	0.61	(0.33)	0.38	(0.39)	0.62
Word Reading	0.33	(0.38)	0.27	(0.34)	0.16
Spelling	0.28	(0.39)	0.25	(0.34)	0.07
Pre-Post Change					
% Correct Common Items					
Letter Names	0.27	(0.36)	0.19	(0.36)	0.23
Letter Sounds	0.44	(0.30)	0.41	(0.28)	0.12
Letter Sound Writing	0.46	(0.32)	0.37	(0.30)	0.29
Word Reading	0.19	(0.24)	0.20	(0.20)	-0.03
Spelling	0.10	(0.21)	0.18	(0.24)	-0.39
% Correct Fast Only					
Letter Names	0.24	(0.30)	0.13	(0.32)	0.36
Letter Sounds	0.45	(0.28)	0.14	(0.17)	1.34
Letter Sound Writing	0.36	(0.26)	0.11	(0.24)	0.98
Word Reading	0.18	(0.29)	0.05	(0.18)	0.50

Spelling	0.11	(0.20)	0.08	(0.22)	0.13

Note. Age = years; Receptive vocab = PPTV-4 raw scores, all other measures are experimenter measures in percent correct; common item assessments include 10 items and fast only assessments have five items.

Table 2

Study 1 Model Results for Pre-Post Change on Common Items Percent Correct

Fixed Effects	Letter Names			Letter Sounds			Ltr Snd Writing			Word Reading			Spelling		
	Coeff	*p*	*d*	*Coeff*	*p*	*d*	*Coeff*	*p*	*d*	*Coeff*	*p*	*d*	*Coeff*	*p*	*d*
Mean Change (%)	**0.22**	**<.001**		**0.42**	**<.001**		**0.43**	**<.001**		**0.20**	**<.001**		**0.15**	**<.001**	
Group (1=Fast, -1=Slow)	0.04	.222	.15	0.01	.606	.07	0.01	.595	.06	0.00	.843	.02	-0.04	.054	-.22
Grade (1=GrK, 1=Gr1)	0.14	.305	.61	0.00	.979	.01	-0.14	.138	-.58	**-0.18**	**<.001**	**-1.09**	**-0.18**	**<.001**	**-1.03**
EL (1=Yes, -1=No)	-0.05	.114	-.20	-0.03	.392	-.13	-0.03	.400	-.12	-0.01	.612	-.07	0.01	.567	.07
Pretest (Z)	-0.11	.389	-.49	**-0.19**	**.002**	**-.97**	**-0.30**	**.002**	**-1.23**	-0.07	.077	-.44	**-0.12**	**.002**	**-.65**
Group * Grade	-0.01	.940	-.04	0.05	.399	.27	0.15	.154	.59	-0.05	.357	-.31	0.02	.629	.10
Group * EL	0.01	.687	.05	0.03	.120	.16	0.00	.933	-.01	0.05	.067	.28	0.02	.191	.10
Group * Pretest	-0.04	.728	-.18	0.03	.614	.16	0.10	.293	.41	-0.06	.251	-.37	0.00	.963	-.01
Random Effects	*Var*	*p*		*Var*	*p*		*Var*	*p*		*Var*	*p*		*Var*	*p*	
Teachers	<.01	.048		<.01	.272		0.01	.033		<.01	>.500		<.01	>.500	
Residual (Students)	0.05			0.04			0.05			0.03			0.03		

Note. N = 65 children across 25 teachers, with 32 in Fast condition and 33 in Slow condition; EL = English learner; 10 items per assessment; change in percent correct analyzed. Significant effects at .05 level in boldface.

Table 3

Study 1 Model Results for Pre-Post Change on Fast Only Items Percent Correct

Fixed Effects	Letter Names			Letter Sounds			Ltr Snd Writing			Word Reading			Spelling		
	Coeff	*p*	*d*	*Coeff*	*p*	*d*	*Coeff*	*p*	*d*	*Coeff*	*p*	*d*	*Coeff*	*p*	*d*
Mean Change (%)	**0.19**	**<.001**		**0.30**	**<.001**		**0.24**	**<.001**		**0.12**	**<.001**		**0.11**	**<.001**	
Group (1=Fast, -1=Slow)	0.03	.268	.13	**0.15**	**<.001**	**.84**	**0.12**	**<.001**	**.59**	**0.05**	**<.001**	**.30**	0.01	.693	.08
Grade (1=GrK, 1=Gr1)	-0.15	.065	-.63	-0.11	.068	-.62	**-0.17**	**.007**	**-.87**	**-0.19**	**<.001**	**-1.10**	**-0.14**	**<.001**	**-.85**
EL (1=Yes, -1=No)	-0.06	.075	-.24	-0.02	.400	-.10	-0.02	.212	-.11	0.00	.860	.02	0.02	.119	.11
Pretest (Z)	**-0.30**	**.001**	**-1.28**	**-0.19**	**.002**	**-1.06**	**-0.21**	**.002**	**-1.05**	**-0.14**	**<.001**	**-.83**	-0.07	.071	-.40
Group * Grade	0.10	.241	.44	**0.20**	**<.001**	**1.14**	**0.10**	**.015**	**.48**	-0.02	.192	-.14	0.03	.689	.16
Group * EL	-0.01	.867	-.02	0.02	.399	.12	0.03	.168	.15	0.05	.090	.29	0.01	.796	.04
Group * Pretest	0.09	.276	.38	0.10	.079	.54	0.03	.374	.15	-0.02	.424	-.14	0.06	.082	.36
Random Effects	*Var*	*p*		*Var*	*p*		*Var*	*p*		*Var*	*p*		*Var*	*p*	
Teachers	<.01	.381		<.01	.323		<.01	>.500		<.01	>.500		<.01	>.500	
Residual (Students)	0.06			0.03			0.04			0.03			0.03		

Note. N = 65 children across 25 teachers, with 32 in Fast condition and 33 in Slow condition; EL = English learner; five items per assessment; change in percent correct analyzed. Significant effects at .05 level in boldface.

Table 4

Study 2 Pretest and Posttest Descriptive Statistics

Measure	Mixed (*n* = 31)		Single (*n* = 30)		M v. S
	M	*(SD)*	*M*	*(SD)*	*d*
Pretest					
Age	5.85	(0.33)	5.97	(0.35)	-0.35
Receptive Vocab	75.29	(23.62)	78.03	(28.62)	-0.10
% Correct Common Items					
Letter Names	0.74	(0.23)	0.68	(0.25)	0.26
Letter Sounds	0.44	(0.34)	0.34	(0.31)	0.30
Letter Sound Writing	0.31	(0.24)	0.27	(0.24)	0.19
Word Reading	0.08	(0.21)	0.01	(0.05)	0.50
Spelling	0.07	(0.15)	0.08	(0.17)	-0.03
% Correct Mixed Only					
Letter Names	0.56	(0.34)	0.47	(0.35)	0.26
Letter Sounds	0.05	(0.12)	0.05	(0.10)	-0.01
Letter Sound Writing	0.06	(0.11)	0.05	(0.12)	0.06
Word Reading	0.13	(0.13)	0.10	(0.12)	0.23
Spelling	0.00	(0.00)	0.00	(0.00)	--
% Correct Single Only					
Letter Names	0.60	(0.33)	0.59	(0.32)	0.02
Letter Sounds	0.33	(0.34)	0.23	(0.29)	0.31
Letter Sound Writing	0.35	(0.39)	0.31	(0.26)	0.14
Word Reading	0.06	(0.18)	0.02	(0.06)	0.30
Spelling	0.03	(0.09)	0.05	(0.17)	-0.13
Posttest					
% Correct Common Items					
Letter Names	0.87	(0.16)	0.84	(0.21)	0.17
Letter Sounds	0.82	(0.20)	0.85	(0.24)	-0.14
Letter Sound Writing	0.56	(0.19)	0.57	(0.18)	-0.06
Word Reading	0.35	(0.32)	0.32	(0.33)	0.10
Spelling	0.27	(0.31)	0.33	(0.33)	-0.18
% Correct Mixed Only					
Letter Names	0.72	(0.30)	0.53	(0.38)	0.54
Letter Sounds	0.79	(0.26)	0.06	(0.14)	3.52
Letter Sound Writing	0.63	(0.32)	0.13	(0.16)	2.00
Word Reading	0.42	(0.31)	0.22	(0.13)	0.87
Spelling	0.14	(0.20)	0.03	(0.09)	0.67
% Correct Single Only					
Letter Names	0.71	(0.32)	0.68	(0.32)	0.08
Letter Sounds	0.53	(0.36)	0.69	(0.35)	-0.45
Letter Sound Writing	0.56	(0.37)	0.66	(0.29)	-0.28
Word Reading	0.25	(0.35)	0.30	(0.36)	-0.14

Spelling	0.18	(0.32)	0.25	(0.30)	-0.23

Note. Age = years; Receptive vocab = PPTV-4 raw scores, all other measures in percent correct; common item assessments include 11 or 12 items; mixed and single only assessments have four items.

Table 5

Study 2 Model Results for Pre-Post Change on Common Items Percent Correct

Fixed Effects	Letter Names			Letter Sounds			Ltr Snd Writing			Word Reading			Spelling		
	Coeff	*p*	*d*	*Coeff*	*p*	*d*	*Coeff*	*p*	*d*	*Coeff*	*p*	*d*	*Coeff*	*p*	*d*
Mean Change (%)	**0.14**	**<.001**		**0.44**	**<.001**		**0.27**	**<.001**		**0.21**	**<.001**		**0.21**	**<.001**	
Group (1=Mixed, -1=Single)	0.00	.832	.03	-0.04	.113	-.15	-0.02	.320	-.09	0.01	.701	.09	-0.03	.284	-.21
EL (1=Yes, -1=No)	0.00	.949	.01	0.01	.812	.03	0.00	.891	.01	0.06	.263	.36	0.07	.088	.58
Pretest (Z)	**-0.15**	**<.001**	**-.94**	**-0.21**	**<.001**	**-.44**	**-0.16**	**<.001**	**-.38**	**-0.24**	**<.001**	**-.78**	0.05	.357	.19
Group * EL	-0.03	.130	-.19	-0.03	.274	-.06	-0.02	.329	-.05	0.00	.959	.00	-0.02	.448	-.08
Group * Pretest	0.04	.156	.25	0.00	.949	.00	0.02	.261	.06	**0.17**	**<.001**	**.54**	**0.05**	**<.001**	**.18**
Random Effects	*Var*	*p*		*Var*	*p*		*Var*	*p*		*Var*	*p*		*Var*	*p*	
Teachers	<.01	>.500		0.04	.351		0.01	>.500		0.02	.018		<.01	>.500	
Residual (Students)	0.03			0.184			0.17			0.07			0.06		

Note. N = 61 children across 22 teachers, with 31 in Mixed condition and 30 in Slow condition; EL = English learner; 11 items per assessment; change in percent correct analyzed. Significant effects at .05 level in boldface.

Table 6

Study 2 Model Results for Pre-Post Change on Mixed Only Items Percent Correct

Fixed Effects	Letter Names			Letter Sounds			Ltr Snd Writing			Word Reading			Spelling		
	Coeff	*p*	*d*	*Coeff*	*p*	*d*	*Coeff*	*p*	*d*	*Coeff*	*p*	*d*	*Coeff*	*p*	*d*
Mean Change (%)	**0.14**	**<.001**		**0.37**	**<.001**		**0.33**	**<.001**		**0.20**	**<.001**		**0.09**	**<.001**	
Group (1=Mixed, -1=Single)	**0.07**	**.037**	**.26**	**0.35**	**<.001**	**3.51**	**0.25**	**<.001**	**2.08**	**0.10**	**.028**	**.86**	**0.06**	**.003**	**.80**
EL (1=Yes, -1=No)	0.02	.687	.06	0.01	.728	.08	0.00	.858	-.03	0.01	.590	.12	-0.02	.363	-.23
Pretest (Z)	**-0.17**	**<.001**	**-.62**	**-0.10**	**.002**	**-.48**	**-0.07**	**<.001**	**-.29**	**-0.08**	**.008**	**-.35**	--	--	
Group * EL	**-0.07**	**.022**	**-.27**	0.04	.186	.18	-0.03	.329	-.12	-0.01	.864	-.02	**-0.03**	**.045**	**-.23**
Group * Pretest	0.01	.804	.04	-0.01	.682	-.06	0.03	.184	.11	0.04	.111	.16	--	--	
Random Effects	*Var*	*p*		*Var*	*p*		*Var*	*p*		*Var*	*p*		*Var*	*p*	
Teachers	0.01	.099		0.01	.056		<.01	.224		<.01	.383		<.01	.286	
Residual (Students)	0.07			0.04			0.06			0.05			0.02		

Note. N = 61 children across 22 teachers, with 31 in Mixed condition and 30 in Slow condition; EL = English learner; four items per assessment; change in percent correct analyzed. Significant effects at .05 level in boldface.

Table 7

Study 2 Model Results for Pre-Post Change on Single Only Items Percent Correct

Fixed Effects	Letter Names			Letter Sounds			Ltr Snd Writing			Word Reading			Spelling		
	Coeff	*p*	*d*	*Coeff*	*p*	*d*	*Coeff*	*p*	*d*	*Coeff*	*p*	*d*	*Coeff*	*p*	*d*
Mean Change (%)	**0.11**	**<.001**		**0.33**	**<.001**		**0.26**	**<.001**		**0.23**	**<.001**		**0.18**	**<.001**	
Group (1=Mixed, -1=Single)	0.00	.880	.02	**-0.11**	**.001**	**-.74**	-0.05	.061	-.20	-0.05	.200	-.33	-0.02	.422	-.17
EL (1=Yes, -1=No)	0.01	.799	.02	0.01	.795	.08	0.03	.475	.10	0.07	.174	.44	0.04	.293	.28
Pretest (Z)	**-0.14**	**<.001**	**-.57**	**-0.16**	**<.001**	**-.56**	**-0.15**	**<.001**	**-.29**	0.01	.891	.03	0.06	.314	.23
Group * EL	-0.03	.323	-.14	**-0.09**	**.030**	**-.31**	**-0.06**	**.029**	**-.11**	-0.06	.095	-.19	-0.03	.325	-.13
Group * Pretest	**0.06**	**.048**	**.26**	0.05	.057	.16	0.04	.236	.07	-0.02	.773	-.05	0.12	.067	.44
Random Effects	*Var*	*p*		*Var*	*p*		*Var*	*p*		*Var*	*p*		*Var*	*p*	
Teachers	<.01	.424		<.01	>.500		<.01	.273		0.01	.191		<.01	.169	
Residual (Students)	0.06			0.08			0.27			0.09			0.07		

Note. N = 61 children across 22 teachers, with 31 in Mixed condition and 30 in Slow condition; EL = English learner; four items per assessment; change in percent correct analyzed. Significant effects at .05 level in boldface.

Supplementary Online Materials

Table S1

Study 1 Grade K Descriptive Statistics by EL and Non-EL Status and Combined

Measure	EL (*n* = 10)				Non-EL (*n* = 24)				Combined (*n* = 34)				Fast vs. Slow
	Fast (*n* = 6)		Slow (*n* = 4)		Fast (*n* = 11)		Slow (*n* =13)		Fast (*n* = 17)		Slow (*n* = 17)		
	M	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*d*
Pretest													
Age	5.92	(0.20)	5.51	(0.40)	5.53	(0.20)	5.67	(0.35)	5.67	(0.27)	5.63	(0.35)	0.12
Receptive Vocab	66.17	(27.92)	47.00	(18.38)	69.82	(31.48)	81.08	(19.77)	68.53	(29.43)	73.06	(24.05)	-0.17
% Correct Common Items													
Letter Names	0.05	(0.08)	0.05	(0.06)	0.05	(0.09)	0.04	(0.07)	0.05	(0.09)	0.04	(0.06)	0.16
Letter Sounds	0.02	(0.04)	0.03	(0.05)	0.03	(0.06)	0.02	(0.04)	0.02	(0.06)	0.02	(0.04)	0.00
Letter Sound Writing	0.02	(0.04)	0.00	(0.00)	0.00	(0.00)	0.02	(0.06)	0.01	(0.02)	0.01	(0.05)	-0.15
Word Reading	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	--
Spelling	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	--
% Correct Fast Only													
Letter Names	0.03	(0.08)	0.05	(0.10)	0.00	(0.00)	0.00	(0.00)	0.01	(0.05)	0.01	(0.05)	0.00
Letter Sounds	0.03	(0.08)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.01	(0.05)	0.00	(0.00)	0.34
Letter Sound Writing	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	--
Word Reading	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	--
Spelling	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	--
Posttest													
% Correct Common Items													
Letter Names	0.50	(0.24)	0.40	(0.22)	0.64	(0.27)	0.49	(0.36)	0.59	(0.26)	0.47	(0.33)	0.40
Letter Sounds	0.68	(0.32)	0.48	(0.25)	0.65	(0.25)	0.65	(0.28)	0.66	(0.27)	0.61	(0.28)	0.17
Letter Sound Writing	0.58	(0.18)	0.40	(0.37)	0.66	(0.30)	0.52	(0.35)	0.64	(0.26)	0.49	(0.35)	0.46
Word Reading	0.13	(0.28)	0.00	(0.00)	0.02	(0.04)	0.14	(0.17)	0.06	(0.17)	0.11	(0.16)	-0.29
Spelling	0.00	(0.00)	0.00	(0.00)	0.03	(0.09)	0.09	(0.20)	0.02	(0.07)	0.07	(0.18)	-0.39
% Correct Fast Only													
Letter Names	0.23	(0.23)	0.25	(0.30)	0.47	(0.29)	0.29	(0.27)	0.39	(0.29)	0.28	(0.27)	0.38

Letter Sounds	0.13	(0.16)	0.10	(0.12)	0.11	(0.14)	0.08	(0.10)	0.12	(0.14)	0.08	(0.10)	0.29
Letter Sound Writing	0.40	(0.18)	0.00	(0.00)	0.42	(0.26)	0.08	(0.19)	0.41	(0.23)	0.06	(0.17)	1.75
Word Reading	0.07	(0.16)	0.00	(0.00)	0.04	(0.08)	0.00	(0.00)	0.05	(0.11)	0.00	(0.00)	0.59
Spelling	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	--
Pre-Post Change													
% Correct Common Items													
Letter Names	0.45	(0.29)	0.35	(0.24)	0.58	(0.26)	0.45	(0.34)	0.54	(0.27)	0.43	(0.32)	0.36
Letter Sounds	0.67	(0.31)	0.45	(0.25)	0.62	(0.26)	0.63	(0.29)	0.64	(0.27)	0.59	(0.29)	0.17
Letter Sound Writing	0.57	(0.16)	0.40	(0.37)	0.66	(0.30)	0.51	(0.38)	0.63	(0.26)	0.48	(0.37)	0.46
Word Reading	0.13	(0.28)	0.00	(0.00)	0.02	(0.04)	0.14	(0.17)	0.06	(0.17)	0.11	(0.16)	-0.29
Spelling	0.00	(0.00)	0.00	(0.00)	0.03	(0.09)	0.09	(0.20)	0.02	(0.07)	0.07	(0.18)	-0.39
% Correct Fast Only													
Letter Names	0.20	(0.22)	0.20	(0.28)	0.47	(0.29)	0.29	(0.27)	0.38	(0.29)	0.27	(0.26)	0.38
Letter Sounds	0.60	(0.28)	0.10	(0.12)	0.62	(0.29)	0.11	(0.16)	0.61	(0.28)	0.11	(0.14)	2.29
Letter Sound Writing	0.40	(0.18)	0.00	(0.00)	0.42	(0.26)	0.08	(0.19)	0.41	(0.23)	0.06	(0.17)	1.75
Word Reading	0.07	(0.16)	0.00	(0.00)	0.04	(0.08)	0.00	(0.00)	0.05	(0.11)	0.00	(0.00)	0.59
Spelling	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	--

Note. Age = years; Receptive vocab = PPTV-4 raw scores, all other measures are experimenter measures in percent correct; common item assessments include 10 items and fast only assessments have five items.

Table S2

Study 1 Grade 1 Descriptive Statistics by EL and Non-EL Status and Combined

Measure	EL (n = 21)				Non-EL (n = 10)				Combined (n = 31)				Fast vs. Slow
	Fast (n = 10)		Slow (n = 11)		Fast (n = 5)		Slow (n = 5)		Fast (n = 15)		Slow (n = 16)		
	M	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*d*
Pretest													
Age	6.52	(0.55)	6.56	(0.33)	6.77	(0.39)	6.47	(0.15)	6.60	(0.51)	6.53	(0.28)	0.17
Receptive Vocab	74.30	(34.89)	80.27	(22.32)	110.80	(20.41)	99.80	(18.95)	86.47	(34.91)	86.38	(22.70)	0.00
% Correct Common Items													
Letter Names	0.75	(0.25)	0.92	(0.14)	0.96	(0.05)	0.92	(0.08)	0.82	(0.23)	0.92	(0.12)	-0.55
Letter Sounds	0.66	(0.29)	0.71	(0.11)	0.74	(0.11)	0.66	(0.05)	0.69	(0.24)	0.69	(0.10)	-0.04
Letter Sound Writing	0.47	(0.24)	0.68	(0.13)	0.76	(0.11)	0.62	(0.11)	0.57	(0.25)	0.66	(0.12)	-0.50
Word Reading	0.35	(0.32)	0.45	(0.30)	0.64	(0.11)	0.40	(0.23)	0.45	(0.30)	0.44	(0.28)	0.03
Spelling	0.39	(0.38)	0.47	(0.32)	0.72	(0.13)	0.40	(0.32)	0.50	(0.35)	0.45	(0.31)	0.15
% Correct Fast Only													
Letter Names	0.62	(0.35)	0.82	(0.21)	0.92	(0.11)	0.88	(0.18)	0.72	(0.32)	0.84	(0.20)	-0.45
Letter Sounds	0.62	(0.26)	0.62	(0.21)	0.68	(0.18)	0.68	(0.11)	0.64	(0.23)	0.64	(0.18)	0.01
Letter Sound Writing	0.48	(0.34)	0.58	(0.32)	0.64	(0.17)	0.52	(0.30)	0.53	(0.30)	0.56	(0.30)	-0.10
Word Reading	0.20	(0.25)	0.51	(0.36)	0.60	(0.20)	0.32	(0.30)	0.33	(0.30)	0.45	(0.35)	-0.36
Spelling	0.30	(0.32)	0.36	(0.27)	0.48	(0.11)	0.32	(0.30)	0.36	(0.27)	0.35	(0.27)	0.04
Posttest													
% Correct Common Items													
Letter Names	0.75	(0.28)	0.81	(0.24)	0.88	(0.16)	0.94	(0.09)	0.79	(0.25)	0.85	(0.21)	-0.25
Letter Sounds	0.89	(0.22)	0.90	(0.12)	0.96	(0.05)	0.94	(0.05)	0.91	(0.18)	0.91	(0.10)	0.01
Letter Sound Writing	0.79	(0.32)	0.91	(0.10)	0.92	(0.08)	0.92	(0.08)	0.83	(0.27)	0.91	(0.10)	-0.40
Word Reading	0.74	(0.25)	0.72	(0.30)	0.88	(0.13)	0.76	(0.43)	0.79	(0.23)	0.73	(0.33)	0.19
Spelling	0.67	(0.39)	0.79	(0.29)	0.72	(0.08)	0.68	(0.33)	0.69	(0.32)	0.76	(0.29)	-0.23
% Correct Fast Only													
Letter Names	0.76	(0.30)	0.76	(0.27)	0.88	(0.18)	0.92	(0.18)	0.80	(0.26)	0.81	(0.25)	-0.05
Letter Sounds	0.42	(0.24)	0.47	(0.13)	0.64	(0.26)	0.52	(0.11)	0.49	(0.26)	0.49	(0.13)	0.03
Letter Sound Writing	0.82	(0.33)	0.69	(0.23)	0.84	(0.17)	0.80	(0.20)	0.83	(0.28)	0.73	(0.22)	0.41

Word Reading	0.66	(0.30)	0.55	(0.30)	0.64	(0.38)	0.60	(0.24)	0.65	(0.32)	0.56	(0.28)	0.31
Spelling	0.58	(0.40)	0.55	(0.22)	0.64	(0.26)	0.48	(0.46)	0.60	(0.35)	0.53	(0.30)	0.23
Pre-Post Change													
% Correct Common Items													
Letter Names	0.00	(0.17)	-0.11	(0.22)	-0.08	(0.18)	0.02	(0.08)	-0.03	(0.17)	-0.07	(0.20)	0.23
Letter Sounds	0.23	(0.19)	0.19	(0.10)	0.22	(0.13)	0.28	(0.04)	0.23	(0.17)	0.22	(0.10)	0.06
Letter Sound Writing	0.32	(0.33)	0.23	(0.16)	0.16	(0.05)	0.30	(0.12)	0.27	(0.27)	0.25	(0.15)	0.08
Word Reading	0.39	(0.26)	0.26	(0.20)	0.24	(0.09)	0.36	(0.22)	0.34	(0.23)	0.29	(0.20)	0.21
Spelling	0.28	(0.29)	0.32	(0.23)	0.00	(0.12)	0.28	(0.29)	0.19	(0.27)	0.31	(0.24)	-0.46
% Correct Fast Only													
Letter Names	0.14	(0.23)	-0.05	(0.32)	-0.04	(0.17)	0.04	(0.30)	0.08	(0.22)	-0.03	(0.31)	0.39
Letter Sounds	0.28	(0.10)	0.15	(0.20)	0.24	(0.22)	0.24	(0.17)	0.27	(0.14)	0.18	(0.19)	0.54
Letter Sound Writing	0.34	(0.31)	0.11	(0.26)	0.20	(0.24)	0.28	(0.36)	0.29	(0.29)	0.16	(0.29)	0.45
Word Reading	0.46	(0.23)	0.04	(0.23)	0.04	(0.43)	0.28	(0.18)	0.32	(0.36)	0.11	(0.24)	0.68
Spelling	0.28	(0.25)	0.18	(0.28)	0.16	(0.22)	0.16	(0.38)	0.24	(0.24)	0.18	(0.30)	0.24

Note. Age = years; Receptive vocab = PPTV-4 raw scores, all other measures are experimenter measures in percent correct; common item assessments include 10 items and fast only assessments have five items.

Table S3

Study 1 Zero-Order, Unadjusted Correlations for Common Item Assessments

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Conditions												
1. Group (1=Fast, -1=Slow)	--											
2. Grade (1=GrK, 1=Gr1)	.02	--										
3. EL (1=Yes, -1=No)	.05	**-.38**	--									
Pretest												
4. Letter Names	-.06	**-.95**	**.32**	--								
5. Letter Sounds	-.02	**-.93**	**.35**	**.95**	--							
6. Letter Sound Writing	-.09	**-.91**	**.28**	**.93**	**.87**	--						
7. Word Reading	.00	**-.75**	.21	**.82**	**.83**	**.78**	--					
8. Spelling	.02	**-.73**	.20	**.80**	**.81**	**.77**	**.94**	--				
Pre-Post Change												
9. Letter Names	.12	**.74**	**-.36**	**-.73**	**-.67**	**-.70**	**-.55**	**-.54**	--			
10. Letter Sounds	.06	**.67**	**-.32**	**-.65**	**-.70**	**-.59**	**-.55**	**-.55**	**.65**	--		
11. Letter Sound Writing	.14	**.48**	-.21	**-.45**	**-.41**	**-.56**	**-.36**	**-.35**	**.64**	**.59**	--	
12. Word Reading	-.01	**-.53**	.22	**.48**	**.47**	**.47**	**.23**	**.26**	-.20	-.15	-.10	--
13. Spelling	-.19	**-.45**	**.26**	**.41**	**.38**	**.37**	.12	.07	-.21	-.15	.02	**.55**

Note. N = 65 children across 25 teachers, with 32 in Fast condition and 33 in Slow condition; EL = English learner; 10 items per assessment; change in percent correct measured. Significant correlations at .05 level in boldface.

Table S4

Study 1 Zero-Order, Unadjusted Correlations for Fast Only Item Assessments

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Conditions												
1. Group (1=Fast, -1=Slow)	--											
2. Grade (1=GrK, 1=Gr1)	.02	--										
3. EL (1=Yes, -1=No)	.05	**-.38**	--									
Pretest												
4. Letter Names	-.08	**-.90**	**.28**	--								
5. Letter Sounds	.00	**-.91**	**.33**	**.94**	--							
6. Letter Sound Writing	-.03	**-.81**	**.28**	**.85**	**.85**	--						
7. Word Reading	-.10	**-.67**	.19	**.78**	**.72**	**.74**	--					
8. Spelling	.00	**-.70**	.21	**.82**	**.75**	**.78**	**.82**	--				
Pre-Post Change												
9. Letter Names	.18	**.48**	**-.28**	**-.58**	**-.51**	**-.51**	**-.50**	**-.47**	--			
10. Letter Sounds	**.56**	**.25**	-.07	**-.28**	**-.32**	**-.28**	-.24	-.19	**.45**	--		
11. Letter Sound Writing	**.45**	.02	-.02	-.06	-.06	**-.29**	-.19	-.08	**.27**	**.67**	--	
12. Word Reading	**.25**	**-.39**	.24	**.31**	**.45**	**.30**	-.13	.17	-.01	.02	.18	--
13. Spelling	.07	**-.49**	**.26**	**.46**	**.48**	**.34**	.21	.17	-.19	-.09	.17	**.35**

Note. N = 65 children across 25 teachers, with 32 in Fast condition and 33 in Slow condition; EL = English learner; five items per assessment; percent correct measured. Significant correlations at .05 level in boldface.

Table S5

Study 2 Descriptive Statistics by EL and Non-EL Status and Combined

Measure	EL (*n* = 34)				Non-EL (*n* = 27)				Combined (*n* = 61)				Mixed vs. Single
	Mixed (*n* = 19)		Single (*n* = 15)		Mixed (*n* = 12)		Single (*n* = 15)		Mixed (*n* = 31)		Single (*n* = 30)		
	M	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*d*
Pretest													
Age	5.91	(0.29)	5.92	(0.39)	5.76	(0.37)	6.01	(0.31)	5.85	(0.33)	5.97	(0.35)	-0.35
Receptive Vocab	66.00	(20.59)	69.67	(31.62)	90.00	(21.03)	86.40	(23.38)	75.29	(23.62)	78.03	(28.62)	-0.10
% Correct Common Items													
Letter Names	0.76	(0.21)	0.66	(0.30)	0.72	(0.28)	0.70	(0.19)	0.74	(0.23)	0.68	(0.25)	0.26
Letter Sounds	0.44	(0.35)	0.42	(0.31)	0.44	(0.34)	0.27	(0.30)	0.44	(0.34)	0.34	(0.31)	0.30
Letter Sound Writing	0.31	(0.25)	0.31	(0.26)	0.31	(0.23)	0.22	(0.23)	0.31	(0.24)	0.27	(0.24)	0.19
Word Reading	0.05	(0.17)	0.00	(0.00)	0.14	(0.25)	0.02	(0.06)	0.08	(0.21)	0.01	(0.05)	0.50
Spelling	0.04	(0.08)	0.04	(0.07)	0.12	(0.22)	0.11	(0.23)	0.07	(0.15)	0.08	(0.17)	-0.03
% Correct Mixed Only													
Letter Names	0.54	(0.31)	0.47	(0.40)	0.58	(0.39)	0.47	(0.31)	0.56	(0.34)	0.47	(0.35)	0.26
Letter Sounds	0.05	(0.13)	0.05	(0.10)	0.04	(0.10)	0.05	(0.10)	0.05	(0.12)	0.05	(0.10)	-0.01
Letter Sound Writing	0.05	(0.10)	0.02	(0.06)	0.06	(0.11)	0.08	(0.15)	0.06	(0.11)	0.05	(0.12)	0.06
Word Reading	0.12	(0.13)	0.10	(0.13)	0.15	(0.13)	0.10	(0.13)	0.13	(0.13)	0.10	(0.12)	0.23
Spelling	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)	--
% Correct Single Only													
Letter Names	0.61	(0.33)	0.57	(0.35)	0.58	(0.34)	0.62	(0.31)	0.60	(0.33)	0.59	(0.32)	0.02
Letter Sounds	0.36	(0.36)	0.28	(0.31)	0.29	(0.33)	0.18	(0.26)	0.33	(0.34)	0.23	(0.29)	0.31
Letter Sound Writing	0.37	(0.38)	0.32	(0.29)	0.33	(0.42)	0.30	(0.24)	0.35	(0.39)	0.31	(0.26)	0.14
Word Reading	0.04	(0.17)	0.00	(0.00)	0.08	(0.19)	0.03	(0.09)	0.06	(0.18)	0.02	(0.06)	0.30
Spelling	0.03	(0.08)	0.02	(0.06)	0.04	(0.10)	0.08	(0.22)	0.03	(0.09)	0.05	(0.17)	-0.13
Posttest													
% Correct Common Items													
Letter Names	0.86	(0.16)	0.85	(0.21)	0.89	(0.18)	0.82	(0.21)	0.87	(0.16)	0.84	(0.21)	0.17
Letter Sounds	0.80	(0.21)	0.91	(0.23)	0.86	(0.19)	0.80	(0.24)	0.82	(0.20)	0.85	(0.24)	-0.14
Letter Sound Writing	0.54	(0.21)	0.60	(0.19)	0.58	(0.17)	0.54	(0.17)	0.56	(0.19)	0.57	(0.18)	-0.06
Word Reading	0.36	(0.35)	0.39	(0.35)	0.33	(0.30)	0.24	(0.30)	0.35	(0.32)	0.32	(0.33)	0.10
Spelling	0.27	(0.31)	0.40	(0.34)	0.27	(0.33)	0.26	(0.32)	0.27	(0.31)	0.33	(0.33)	-0.18

% Correct Mixed Only													
Letter Names	0.67	(0.32)	0.58	(0.35)	0.79	(0.26)	0.48	(0.42)	0.72	(0.30)	0.53	(0.38)	0.54
Letter Sounds	0.82	(0.26)	0.02	(0.06)	0.75	(0.26)	0.10	(0.18)	0.79	(0.26)	0.06	(0.14)	3.52
Letter Sound Writing	0.62	(0.32)	0.15	(0.16)	0.65	(0.34)	0.10	(0.16)	0.63	(0.32)	0.13	(0.16)	2.00
Word Reading	0.42	(0.31)	0.23	(0.11)	0.42	(0.31)	0.20	(0.14)	0.42	(0.31)	0.22	(0.13)	0.87
Spelling	0.11	(0.17)	0.05	(0.10)	0.19	(0.24)	0.02	(0.06)	0.14	(0.20)	0.03	(0.09)	0.67
% Correct Single Only													
Letter Names	0.68	(0.33)	0.70	(0.34)	0.75	(0.30)	0.67	(0.31)	0.71	(0.32)	0.68	(0.32)	0.08
Letter Sounds	0.49	(0.38)	0.82	(0.31)	0.60	(0.33)	0.57	(0.35)	0.53	(0.36)	0.69	(0.35)	-0.45
Letter Sound Writing	0.55	(0.39)	0.75	(0.30)	0.58	(0.36)	0.57	(0.26)	0.56	(0.37)	0.66	(0.29)	-0.28
Word Reading	0.25	(0.33)	0.42	(0.37)	0.25	(0.38)	0.18	(0.32)	0.25	(0.35)	0.30	(0.36)	-0.14
Spelling	0.17	(0.28)	0.32	(0.32)	0.19	(0.39)	0.18	(0.27)	0.18	(0.32)	0.25	(0.30)	-0.23
Pre-Post Change													
% Correct Common Items													
Letter Names	0.10	(0.16)	0.19	(0.27)	0.17	(0.15)	0.12	(0.29)	0.13	(0.16)	0.16	(0.28)	-0.14
Letter Sounds	0.36	(0.32)	0.49	(0.30)	0.42	(0.27)	0.53	(0.28)	0.38	(0.30)	0.51	(0.28)	-0.44
Letter Sound Writing	0.23	(0.25)	0.29	(0.25)	0.27	(0.18)	0.32	(0.23)	0.25	(0.23)	0.30	(0.24)	-0.25
Word Reading	0.32	(0.34)	0.39	(0.35)	0.19	(0.27)	0.23	(0.32)	0.27	(0.32)	0.31	(0.34)	-0.13
Spelling	0.23	(0.26)	0.36	(0.33)	0.15	(0.19)	0.14	(0.23)	0.20	(0.23)	0.25	(0.30)	-0.20
% Correct Mixed Only													
Letter Names	0.13	(0.28)	0.12	(0.43)	0.21	(0.28)	0.02	(0.31)	0.16	(0.28)	0.07	(0.37)	0.29
Letter Sounds	0.76	(0.27)	-0.03	(0.13)	0.71	(0.33)	0.05	(0.17)	0.74	(0.29)	0.01	(0.15)	3.16
Letter Sound Writing	0.57	(0.32)	0.13	(0.16)	0.58	(0.33)	0.02	(0.22)	0.57	(0.32)	0.08	(0.20)	1.89
Word Reading	0.30	(0.32)	0.13	(0.16)	0.27	(0.27)	0.10	(0.18)	0.29	(0.30)	0.12	(0.17)	0.72
Spelling	0.11	(0.17)	0.05	(0.10)	0.19	(0.24)	0.02	(0.06)	0.14	(0.20)	0.03	(0.09)	0.67
% Correct Single Only													
Letter Names	0.08	(0.22)	0.13	(0.30)	0.17	(0.22)	0.05	(0.40)	0.11	(0.22)	0.09	(0.35)	0.07
Letter Sounds	0.13	(0.33)	0.53	(0.33)	0.31	(0.30)	0.38	(0.40)	0.20	(0.33)	0.46	(0.37)	-0.74
Letter Sound Writing	0.18	(0.36)	0.43	(0.29)	0.25	(0.26)	0.27	(0.32)	0.21	(0.32)	0.35	(0.31)	-0.44
Word Reading	0.21	(0.28)	0.42	(0.37)	0.17	(0.34)	0.15	(0.30)	0.19	(0.30)	0.28	(0.36)	-0.27
Spelling	0.14	(0.27)	0.30	(0.32)	0.15	(0.29)	0.10	(0.26)	0.15	(0.27)	0.20	(0.30)	-0.19

Note. Age = years; Receptive vocab = PPTV-4 raw scores, all other measures are experimenter measures in percent correct; common item assessments include 11 items for letter names, sounds, and sound writing, and 12 items for word reading and spelling; mixed and single only assessments have four items.

Table S6

Study 2 Zero-Order, Unadjusted Correlations for Common Item Assessments

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Conditions											
1. Group (1=Mixed, -1=Single)	--										
2. EL (1=Yes, -1=No)	.11	--									
Pretest											
3. Letter Names	.13	.01	--								
4. Letter Sounds	.15	.13	**.40**	--							
5. Letter Sound Writing	.10	.11	**.46**	**.79**	--						
6. Word Reading	.24	-.14	**.27**	**.45**	**.38**	--					
7. Spelling	-.02	-.23	**.31**	**.51**	**.51**	**.44**	--				
Pre-Post Change											
8. Letter Names	-.07	.00	**-.69**	-.03	-.21	-.14	-.12	--			
9. Letter Sounds	-.22	-.10	-.04	**-.76**	**-.57**	**-.39**	**-.38**	.02	--		
10. Letter Sound Writing	-.12	-.08	-.11	**-.44**	**-.69**	-.20	-.24	**.27**	**.61**	--	
11. Word Reading	-.07	.21	.07	**.41**	**.27**	-.25	.18	.21	-.17	.05	--
12. Spelling	-.10	**.26**	.21	**.50**	**.42**	.16	.08	.06	**-.29**	-.10	**.59**

Note. N = 61 children across 22 teachers, with 31 in Mixed condition and 30 in Slow condition; EL = English learner; 11 items per assessment; percent correct measured. Significant correlations at .05 level in boldface.

Table S7

Study 2 Zero-Order, Unadjusted Correlations for Fast Item Assessments

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Conditions											
1. Group (1=Mixed, -1=Single)	--										
2. EL (1=Yes, -1=No)	.11	--									
Pretest											
3. Letter Names	.13	-.02	--								
4. Letter Sounds	-.01	.02	**.34**	--							
5. Letter Sound Writing	.03	-.17	**.28**	**.37**	--						
6. Word Reading	.12	-.04	**.30**	**.34**	**.30**	--					
7. Spelling	--	--	--	--	--	--	--				
Pre-Post Change											
8. Letter Names	.15	.04	**-.45**	**-.30**	-.22	-.20	--	--			
9. Letter Sounds	**.85**	.08	-.05	-.24	-.08	.02	--	.23	--		
10. Letter Sound Writing	**.69**	.15	**.30**	.01	-.20	**.30**	--	-.01	**.56**	--	
11. Word Reading	**.34**	.10	.17	.01	-.13	**-.26**	--	.08	**.34**	**.33**	--
12. Spelling	**.32**	-.04	**.33**	-.01	.14	**.27**	--	.03	.17	**.41**	**.37**

Note. N = 61 children across 22 teachers, with 31 in Mixed condition and 30 in Slow condition; EL = English learner; four items per assessment; percent correct measured. Significant correlations at .05 level in boldface.

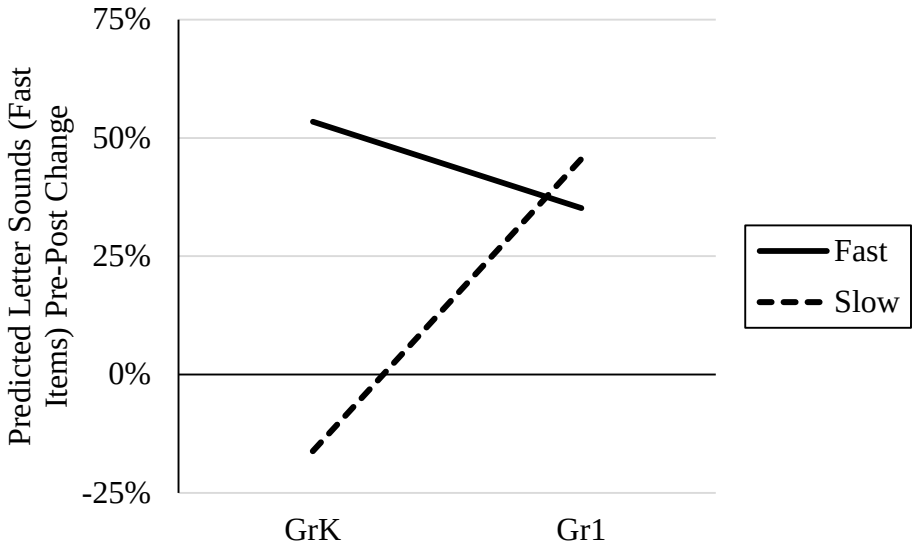
Table S8

Study 2 Zero-Order, Unadjusted Correlations for Single Item Assessments

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Conditions											
1. Group (1=Mixed, -1=Single)	--										
2. EL (1=Yes, -1=No)	.11	--									
Pretest											
3. Letter Names	.01	-.02	--								
4. Letter Sounds	.15	.15	**.25**	--							
5. Letter Sound Writing	.07	.05	**.39**	**.76**	--						
6. Word Reading	.15	-.12	.16	**.45**	**.35**	--					
7. Spelling	-.07	-.16	.08	**.34**	**.38**	.21	--				
Pre-Post Change											
8. Letter Names	.04	.00	-.47	.03	-.08	-.04	.11	--			
9. Letter Sounds	**-.35**	-.06	.17	-.46	-.22	-.14	-.07	.15	--		
10. Letter Sound Writing	-.22	.05	.14	-.22	**-.47**	-.07	-.15	.01	**.47**	--	
11. Word Reading	-.14	.22	.13	**.31**	**.41**	-.04	**.25**	.14	.14	.05	--
12. Spelling	-.10	.16	.18	**.31**	**.37**	**.29**	-.05	.06	.12	.09	**.66**

Note. N = 61 children across 22 teachers, with 31 in Mixed condition and 30 in Slow condition; EL = English learner; four items per assessment; percent correct measured. Significant correlations at .05 level in boldface.

Panel A



Panel B

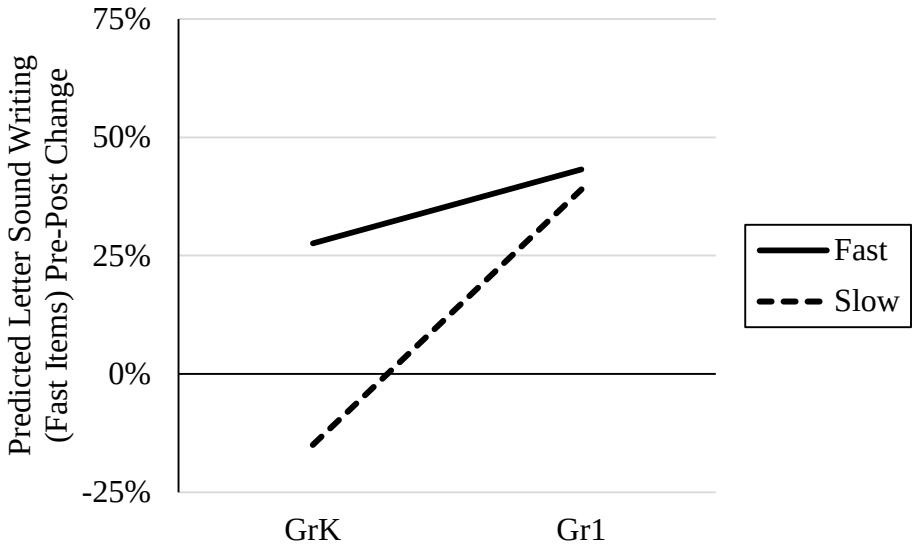
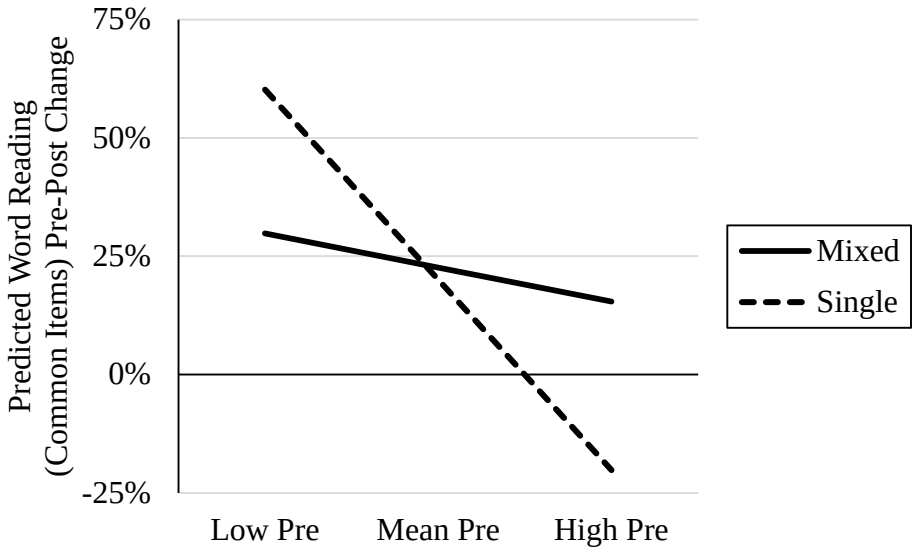


Figure S1 Study 1 group-by-grade interactions on letter sounds (Panel A) and letter sound writing (Panel B) pre-post change for Fast Only items

Panel A



Panel B

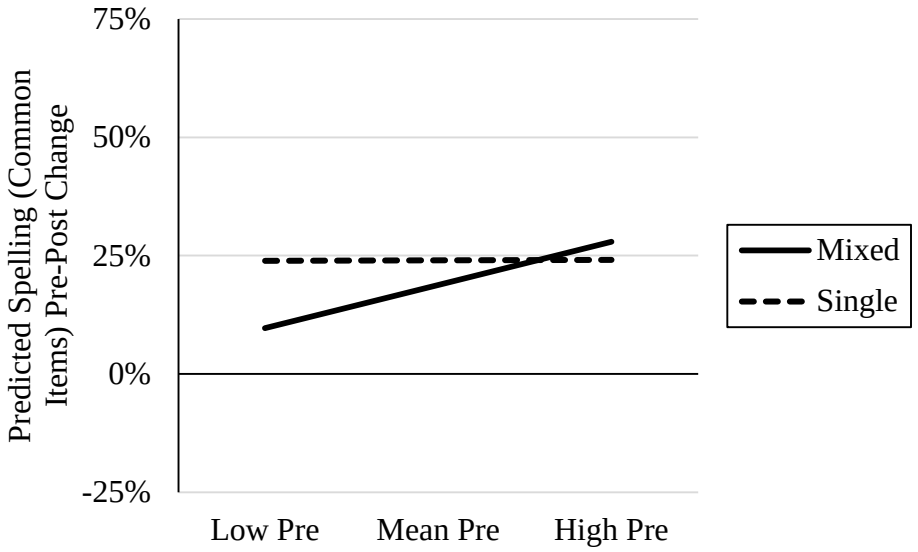
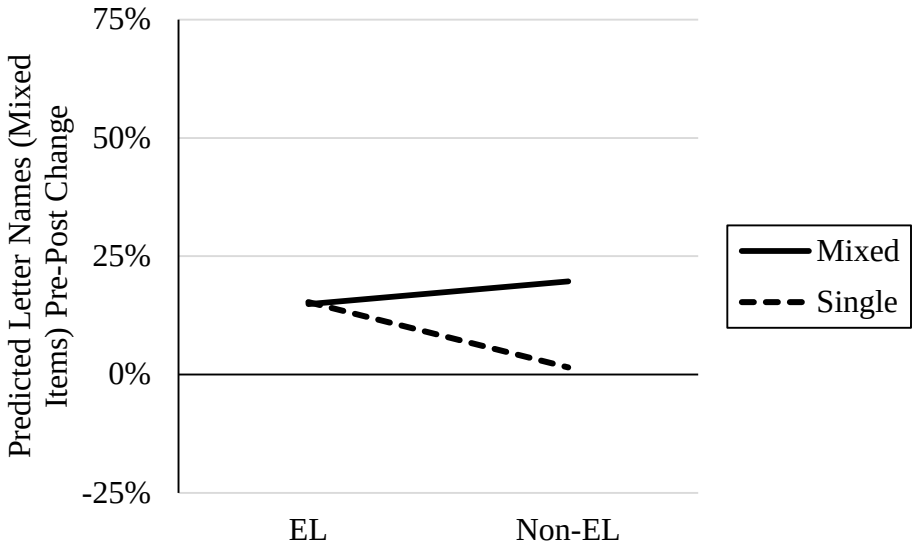


Figure S2 Study 2 group-by-pretest interactions on word reading (Panel A) and spelling (Panel B) pre-post change for common items

Panel A



Panel B

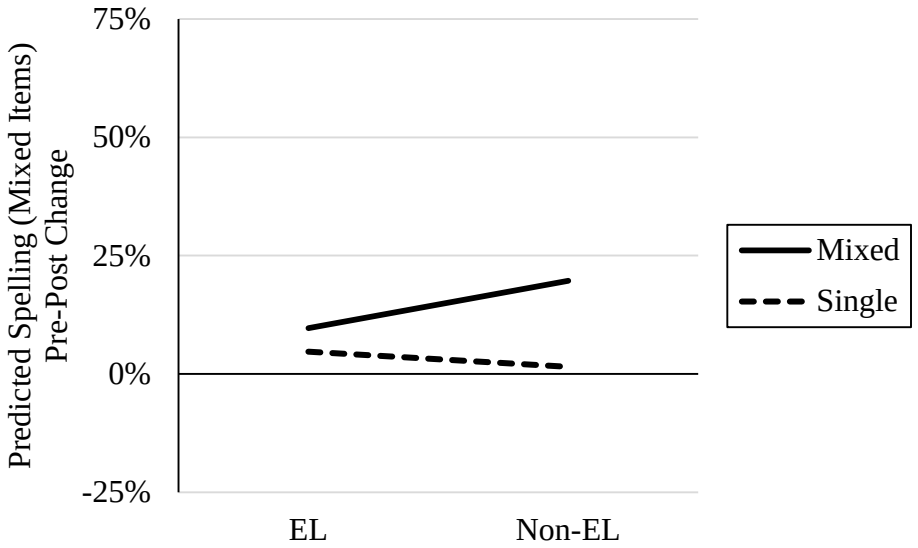
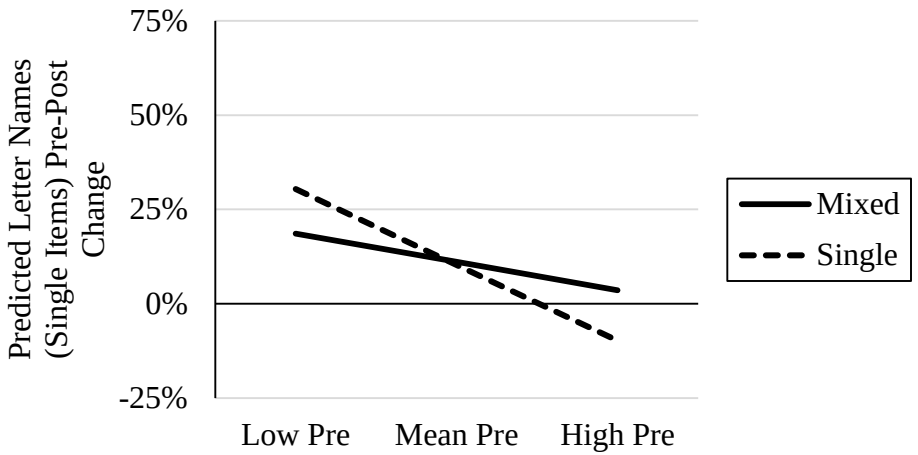
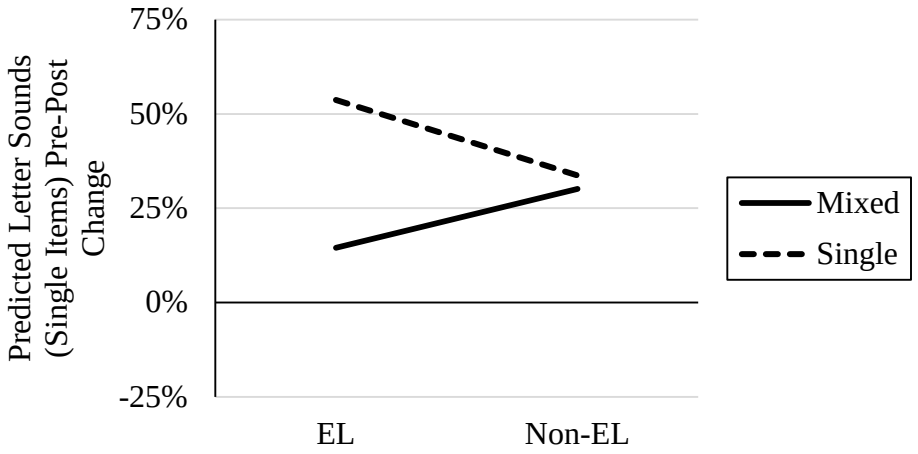


Figure S3 Study 2 group-by-EL interactions on letter names (Panel A) and spelling (Panel B) pre-post change for mixed items

Panel A



Panel B



Panel C

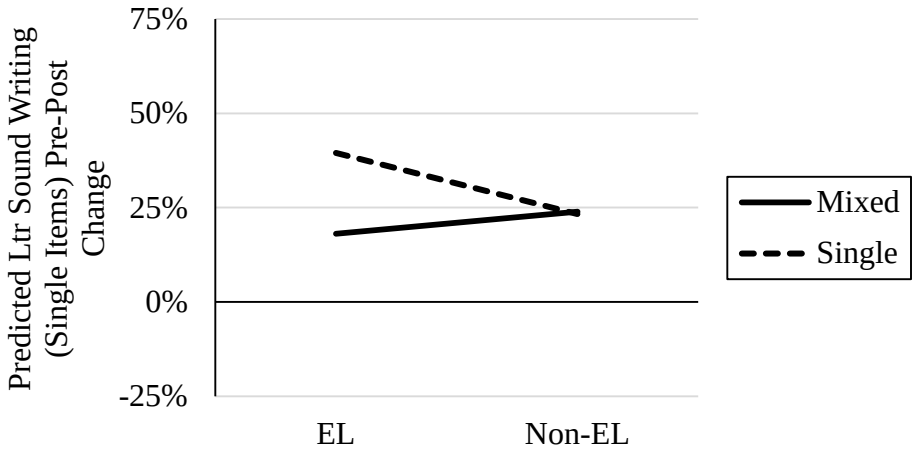


Figure S4 Study 2 group-by-pretest interaction on letter name (Panel A), group-by-EL interactions on letter sounds (Panel B), and letter sound writing (Panel C) pre-post change for single items