This is a post-peer-review, pre-copyedit version of an article published in *Reading and Writing: An International Journal*. The final authenticated version was available online first on January 30, 2021 at: https://doi.org/10.1007/s11145-021-10134-9

Introducing Phonics to Learners Who Struggle: Content and Embedded Cognitive Elements

Patricia F. Vadasy

Oregon Research Institute

Elizabeth A. Sanders

University of Washington

Author Note

Patricia F. Vadasy, Oregon Research Institute. Elizabeth A. Sanders, University of Washington.

We wish to thank Sueanne Sluis, project manager, and the research assistant instructors for their expertise and dedication during this intervention. This research was supported by the Institute of Education Sciences (IES), U.S. Department of Education, Grant No. R305A180005. Any opinions, findings, and recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the Institute of Education Sciences.

Correspondence should be addressed to Patricia Vadasy, Oregon Research Institute, 1776 Millrace Drive, Eugene, OR 97403, USA. patriciav@ori.org

Abstract

A brief experiment was designed to examine cognitive flexibility practice embedded in beginning phonics instruction for kindergarteners with limited early literacy learning. Previously tested phonics content included single- and high-frequency two-letter grapheme-phoneme correspondences (GPCs), introduced at a rate of 2-4 correspondences per week. Children entered with minimal alphabet knowledge and were randomly assigned within classrooms, stratified by English Learner (EL) status, to one of two conditions delivered individually over six weeks: Plain explicit phonics (n = 35) or Flex instruction (n = 33) which covered the same Plain phonics content but with teaching tasks for practice switching letter or word dimensions. Results showed that kindergarteners in the Plain condition made significantly greater gains on tasks of writing taught letter-sound correspondences and spelling. Findings inform a rate for introducing letter-sound correspondences and learning of mixed-size GPCs. The Plain explicit phonics focus on initial accuracy had benefits for encoding taught letter correspondences. Findings support future research on effective tasks to develop reading-related cognitive flexibility in beginners, the optimal timing of this practice, and whether it benefits in particular those children most at risk for acquiring this foundational alphabetic knowledge.

Keywords: alphabet, decoding, cognitive flexibility, grapheme-phoneme correspondences, kindergarten, phonics

Teaching Phonics Better for Learners Who Struggle: Content and Embedded Cognitive Elements

The science of how we learn to read makes clear that reading is an unnatural and relatively recent human activity, and one that is much more difficult for some children. Decades of research on reading interventions also show that the most effective approaches to beginning word reading, a foundation for a skilled reader, are characterized by explicit instruction and practice in alphabetics and phonics (Castles et al., 2018). When provided with this instruction, most children learn essential early reading skills, including decoding and spelling. Research strongly supports explicit methods of phonics instruction (Foorman et al., 1998; Steubing et al., 2008). However, even provided with research-based explicit instruction, too many at risk children fail to respond and continue to struggle (Al Otaiba & Fuchs, 2006).

This warrants a closer look at features of beginning phonics instruction that might be taught more effectively, the “how” and the “when” of teaching initial knowledge of letter-sound associations and phonemic decoding (Seidenberg et al., 2020). The content and sequence of many effective reading interventions have been guided by the phonological deficit hypothesis (Bowyer-Crane et al., 2008; Vellutino et al., 2004) and the phonological processes involved in reading words. The role of the orthographic knowledge and other cognitive processes involved in the earliest stages of phonemic decoding have less often been drawn upon to inform beginning word reading instruction for children with the most limited alphabetic coding skills. Orthographic knowledge includes word-specific representations as well as knowledge of orthographic patterns that form mental graphemic representations (MGRs) (Conrad et al., 2013; Perfetti, 1992; Rothe et al., 2014) or mental orthographic representations (MORs) (e.g., Apel, 2009). These lexical acquisition systems are “mutually facilitative (Compton et al., 2014, p. 60;

also see van den Broeck & Geudens, 2012; Wright & Ehri, 2007; Ziegler & Goswami, 2005) as described by Ehri's (2005, 2014) theory of orthographic mapping. Although access to high quality grapheme representations is critical for skilled word reading, the unique role of orthographic knowledge is often overshadowed in *beginning* reading instruction by a focus on phonemic decoding (see Brady, 2011). There is increasing understanding that individual differences in children's acquisition of MGRs influence reading and spelling outcomes (Siegelman et al., 2020; Wolter & Apel, 2010).

Word reading difficulties accrue from aggregate risk factors that vary in severity and impact (Seidenberg, 2013). Large numbers of children who enter school less prepared to learn these foundations of reading due to environmental and experiential deficits have limited print exposure and the related attentional skill associated with reading development (Share, 2008). Early experience and exposures to printed words afford knowledge of the statistical properties of words, including knowledge of letter identities, patterns, sequential dependencies, and structural redundancies (Dehaene et al., 2005; Grainger & Ziegler, 2011). Even the early spellings of preschool children reflect the statistical spelling patterns of the texts to which they have been exposed in their language environment (Kessler et al., 2012). One question is how to help children at-risk for reading difficulties efficiently acquire these initial representations and knowledge of English orthography to minimize early learning differences.

Seeking improvements in current teaching practices in the most effective early reading interventions are warranted to better the outcomes of the large number of at-risk struggling students. Although many interventions feature explicit instruction in letter-sound correspondences, decoding, and spelling, a range (2%-80%) of children at risk for reading difficulties do not respond adequately (Al Otaiba & Fuchs, 2006; Torgesen, 2000). In the current study we examine the teaching and learning of GPCs with children in the pre-alphabetic stage of word reading who are initially being introduced to GPCs, and learning to accomplish grapheme-by-grapheme decoding (Ehri, 2005). Three features of early phonics learning contexts recommend examination: teaching rate, GPC content, and cognitive processes that influence response to reading instruction.

Teaching Rate

Alphabet knowledge is often introduced at a rate of one letter correspondence a week (Neuman, 2006), although children learn the correspondences when taught at a faster rate. In a naturalistic study comparing two rates of introducing letter names and sounds to high risk kindergarteners--a rate of one letter a day with added time for difficult letters and cycles of review--or the traditional rate of one letter a week, the proportion of students at year end who were at risk at posttest was significantly lower for the faster rate than the slower rate. The rate of one letter per day, with added attention to more difficult letters and review established an alphabetic foundation sooner and allowed struggling learners to engage in beneficial discrimination practice (Jones & Reutzel, 2012). Introducing a larger group of high frequency letters makes it possible to create more natural decodable texts which are most valuable for struggling beginners needing support in the transition to applying their alphabet knowledge to decoding words in context (Mesmer, 1999). In the current study we introduce grapheme-phoneme correspondences (GPCs) at a recommended rate of 2-4 relations per week (Carnine et al., 1997; Chard & Osborn, 1999; Jones & Reutzel, 2012). We also base the rate on previous research on variations in K-1 phonics interventions (Vadasy & Sanders, 2013, 2012, 2011, 2010; Vadasy et al., 2008, 2007, 2006, 2005).

GPC Content

Difficulties in forming strong automatic *initial* connections between orthographic units and phonological representations (Castles et al., 2003) are of concern because they may delay the momentum of self-teaching (Share, 2004). Accurate and efficient access to GPCs necessary for fluent reading and writing is developed through explicit, intense instruction (Apel, 2009; Ehri et al., 2009). A model of early spelling development also holds that statistical learning accounts for learning the graphotactic regularities of English word spelling (Treiman & Cassar, 1997; see reviews by Deacon et al., 2008; Perruchet & Pacton, 2006). School children are most often introduced to the individual letters of the alphabet before they are introduced to two-letter GPCs. In the current study we teach an orderly, specified sequence of high frequency one- and two-letter GPCs and their application in reading and spelling tasks. Kindergarteners successfully learned this mixed letter content in an earlier study (Vadasy & Sanders, 2020). Prioritizing instruction of high frequency GPCs offers benefits for children with limited early literacy experiences, less likely to have acquired implicit knowledge of the statistical structure of English letter-sound correspondences. Text analyses indicates that alphabet instruction characterized by judicious selection of high frequency GPCs may hasten these children's access to reading in natural text contexts (Solity & Vousden, 2009). Instruction would be designed to introduce GPCs that children practice to accuracy in a contextual continuum from isolated correspondences, words, controlled texts, and authentic texts which then more quickly become accessible.

Cognitive Reading Skills

Under the umbrella of executive function (EF) are a number of cognitive functions that affect learning, often grouped into working memory, inhibition, and cognitive flexibility, the ability to switch between multiple rule sets, operations, and mental states (Cartwright et al.,2010; Fuhs et al.,2014; Vitiello et al., 2011; Welsh et al., 2010). Initial phonics learning requires coordinating and flexibly processing multiple features of words and grain size variations in the orthography. General measures of cognitive flexibility (matrix classification tasks) are related to emergent literacy skills in preschoolers (Bierman et al., 2008), and reading-specific flexibility has been found to improve between Grades 1 and 2 when children establish word reading skills, and to independently predict reading comprehension (Cartwright, 2002). Reading comprehension most clearly draws upon cognitive flexibility in requiring readers to attend to both the grapho-phonemic and semantic features of words.

Training has been shown to improve young children's cognitive abilities (Diamond et al.,2007; Dowsett & Livesey, 2000; Karbach & Kray, 2009), and reading-related EF training has demonstrated benefits for reading comprehension, including at-risk and struggling readers (Cartwright, 2002; Dias & Seabra, 2017; Fuchs et al., 2018; Peng & Fuchs, 2017). Instruction that enlists and enhances these cognitive processes may benefit children with beginning word reading and spelling difficulties. Corrective feedback to support flexible processing of word features improved word reading and establishing orthographic representations for second graders (Martin-Chang et al., 2017). Cartwright et al. (2017) found that task-switching practice helped young readers manage and retrieve orthographic/phonological and lexical information, and Guajardo and Cartwright (2016) reported a moderate association between task switching and decoding in preschoolers. Others have found that attentional control allows young children to shift attention from the word form to the word meaning, and influences early word decoding (van de Sande et al., 2013). Cole et al. (2014) found that French second-grade beginning readers' performance on a reading-specific flexibility task predicted word reading as well as comprehension of texts.

Timing of Cognitive Skills Practice. Cognitive training tasks to develop working memory and executive control have most often been integrated into reading instruction for older students. For example, Cartwright demonstrated benefits of brief training in flexibly processing both graphophonological and semantic features of printed words with school-age (Cartwright 2002, 2006; Cartwright et al., 2017; Cartwright et al., 2020), and college-age students (Cartwright et al.,2006). Peng and Fuchs (2017) found that working memory practice incorporated into a reading intervention for at-risk first graders improved listening comprehension and retell outcomes compared to a business-as-usual and a working memory training only control group. We are not aware of interventions that embed this type of cognitive training into initial kindergarten phonics instruction.

Reading comprehension clearly draws upon central executive skills, including flexible thinking. Flexibility is also involved in early reading tasks. Beginning decoding and spelling require attention to grapho-phonemic correspondences and word meanings, and children initially learn inhibitory control to suppress letter names in favor of letter sounds for decoding (that some children with limited early literacy experience struggle with these alphabet features, attempting to blend using the letter names, has not been often noted). Learning these visual-verbal associations is a challenging learning task of activating both phonological and orthographic processing (Ober et al., 2020). A bidirectional theory of academic learning and cognition (Peng & Goodrich, 2020; Peng & Kievit, 2020) suggests that learning academic tasks like decoding both draws upon children's cognitive abilities and improves them (Kievit et al.,2019; Peng et al., 2019). The primary question addressed in the current study is whether embedding cognitive skills practice into early phonics activities may improve learning for kindergarten beginners who struggle to learn letter-sound correspondences and beginning decoding (Kilpatrick, 2015;

Seidenberg, 2013; Vadasy & Sanders, 2020) when compared to phonics instruction without embedded cognitive practice. A secondary question is whether pretests, attendance, or EL status predict outcomes.

Methods

Participants

Participants were drawn from one all-kindergarten school in the Pacific Northwest, U.S. Students were identified by the school for the study based on their September literacy screening for alphabet knowledge, and subsequent teacher confirmation and referral. All students identified scored fewer than three letter names or sounds on the school screen. The school sent home a parent information letter (translated into three major languages) for all identified students, and teachers informed us of any parents who chose to "opt out."

The initial sample included N = 73 consented children from 22 classrooms who were randomly assigned, within classroom and English learner (EL) status, to one of two experimental conditions (Flex n = 36, or Plain instruction, n = 37). (EL status was determined by whether a language other than English was spoken at home.) After attrition due to chronic absences or moving from the school (n = 3 and 2 in Flex and Plain, respectively), the final sample included N = 68 children from 22 classrooms: 33 in the Flex condition and 35 in the Plain. There were 32 (47%) females, 12 (18%) EL children, and 9 (13%) children of color. The mean age at pretest was 5.65 years (SD = 0.48). Multilevel model tests showed no significant differences between conditions on gender, EL status, or child of color status (using generalized linear modeling), nor were there differences on age or pretest (using linear modeling); all coefficient p-values > .10.

Instructors. Children's assignment to their instructor was based on school scheduling convenience. There were nine instructors; each instructor served five to nine children daily (instructors served the same set of children throughout the intervention period), with approximately half of each instructor's assigned children in each of the two conditions.

General Procedures

A team of nine research assistant instructors had previous training and classroom experience, including former classroom teachers and paraeducators. Instructors were provided a set of the lessons for homework study and practice prior to an all-day training session in which the first author modeled lesson delivery, correction procedures, and pacing. Several pairs of instructors modeled lesson delivery, and all were observed practicing lesson delivery and were provided feedback. Trainers provided individual feedback based on the observations for added study, and all instructors practiced teaching the lessons with a young child before instruction began. During and after their homework, the instructors shared questions by e-mail, and answers and feedback were shared with the entire team. Training emphasized instructional delivery, including, explicating all new letter content and skills, including new letter sounds, and new or difficult skills like blending or segmenting. Instructors were trained to model the sounds and skills, have the student say or do the activity with the instructor, and then have the student say or do the skill independently, with individualized scaffolding and practice for each student. If a student struggled to provide a letter sound, the instructor isolated the letter, and asked the student "what sound." If the student still could not supply the sound, the instructor provided the sound, had the student say it in unison, say it alone, and then the instructor provided added practice opportunities for difficult sounds. Researchers on site daily met with instructors for informal lunch meetings and individual coaching, and shared instructional tips in weekly e-mails.

A team of six research assistant assessors with previous testing experience included former teachers, a school psychologist, a school principal, and teacher trainer. Assessors were trained in a half-day session in which assessments were demonstrated by the researchers, and the assessors paired up to practice measures while researchers observed and shared feedback. Assessors were also given homework to practice administering the entire assessment package with a young child, and researchers provided added feedback to address questions. 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.

Materials and Procedures

Two sets of lessons, Plain and Flex, were prepared, each with similar teaching activities. The 10 brief teaching tasks reflected widely used activities to explicitly teach letter sounds, phoneme segmenting, and phoneme blending, and the rate of introducing and teaching GPCs was tested in an earlier study (Vadasy & Sanders, 2020). The lesson activity sequence moved from learning the isolated letters, application to blending and spelling, sorting words, letter fluency practice, and reading words in short sentence contexts. The focus in Plain lessons was on varied activities to practice matching printed letters and sounds. The Flex lessons included brief practice identifying both letter names and sounds, and one activity to practice more automatic naming of mixed names and sounds. Flex lessons featured variations in four tasks that required students to practice flexible thinking and inhibitory control in the phonics activities. In three GPC learning activities, Flex students switched dimensions of letter features by alternately identifying the letter name or letter sound; finding a target letter in varied word positions (first, last, middle); and quickly identifying letter names or sounds in a printed array of taught letters. Beginning readers with the least early literacy have little experience with stimuli like letters that have two labels (names and sounds). Finally, Flex students also practiced sorting words not only by initial sound (as in Plain lessons) but by phonemic and meaning dimensions (last sound, semantic category). The sorting practice was similar to traditional sorting tasks that require children to sort picture cards according to two dimensions (e.g., color and kind).

Lessons were scripted, and instruction was provided in 20-minute sessions, with the instructor working one-to-one with each student. Instruction occurred outside the classroom, in areas designated for tutoring or small group instruction, or in small rooms or spaces outside the classroom.

Children were taught the same 13 letter correspondences in both conditions (a, s, t, oo, c, m, b, i, o, ee, p, sh, d). The number of correspondences introduced each week were: 4, 2, 2, 2, 2, 1. Lesson pages displayed instructor directions in a column on the right side of a page, and the letter and word item stimuli for student practice in large print on the left side of the page. Other materials used were grid paper and letter tiles for phoneme-grapheme spelling practice, laminated segmenting boxes, and index cards. Children in both conditions practiced immediately applying knowledge of taught correspondences to decoding and spelling tasks. The ten basic teaching activities are described, with Flex variations described for four activities.

Say and Write the Sounds. The instructor introduced and modeled new letter sounds, and the student repeated each sound. For the first row the student pointed to each letter and said the name and sound, and the student then pointed to each letter in an array of new and previously taught letters in 5-6 rows of 5 letters each and said each sound. Letters that were newly introduced were always featured 4 times in the array, with cumulative review of previously taught letters. The instructor then dictated the new sound for the student to write.

In the Flex lessons, using the same array of letters, the instructor alternated for each row asking the student to point to each letter and say either the name or the sound.

Blending. For the first three weeks of instruction, the instructor demonstrated blending four words composed of taught letters. After pointing to each sound and blending the sounds the instructor asked the student to point and blend the sounds and say the word fast. Then the student demonstrated the task. The student then identified the first and last sounds in each word.

Word Reading. Referring to a set of 9 words with taught letters, the instructor pointed to a letter in a word and asked the student to say the sound, and then read the word. The instructor varied pointing to letters in each word position, and practice included 3-5 rows of words.

In the Flex lessons, the instructor dictated a letter sound (without pointing to the letter) and asked the student to find that letter in the set of words, point, say the sound, and read the word. The student practiced recognizing the letters in the contexts of the same 3-5 rows of words used in the Plain lessons.

Word Sort. Using a set of 8 word cards, the instructor asked the student to sound out and read the words, sort the words by initial sound, and then say the first sound and read the words in each pile.

In the Flex lessons, the student sorted the same word cards used in the Plain lessons by initial and last sound, and by semantic category (animal words, other categories). To scaffold the semantic sort for students with limited vocabulary and English proficiency, the instructor told the word meaning after the first reading of the word. For example, if the semantic sort asked the student to put the words that were a boy's name in one pile, when the words were first read the instructor would point out that "Sam is a boy's name. Tim is a boy's name."

Segmenting. Displaying letter tiles for taught words, the instructor asked the student to find the letter tiles for 5-8 words. For each word the student found and placed each tile in the correct segmenting box, pointed and said each sound, and then read the word.

Spelling. The instructor dictated 4-8 words, the student repeated each word, then the student spelled the word by placing letter tiles in the segmenting boxes, and read the word.

Reading Words in Context. Using two short sentences with words constructed of mostly taught letters, the instructor read the sentence aloud with the student following, student and instructor pointed and read each sentence together, and the student read the sentence with support as needed.

Quick Find. Using an array of taught letters arranged randomly in 5-8 rows, the instructor dictated a sound and the student pointed to the letters in the array that match the sound. Then the student pointed to each letter in each row saying each sound.

In the Flex lessons, using the same letter grid used in the Plain lessons, the student pointed to each letter and alternated saying the name or the sound for each letter in the rows.

Find the Sound. Using letter tiles and segmenting boxes, the instructor set out one letter tile at a time and prompted the student to point to the box that matched the sound in a word. For each taught sound, the student practiced with two words. For example, "Point to the box where you hear the sound /c/ in *mac*. In *cat*."

Find the Word. Using two sentences that featured a word with a recently taught letter, the instructor helped the student select the missing word from four choices. For example, "This sentence is missing a word (instructor reads the sentence with the correct word that goes in the blank). Mac has a furry pet ____ (*cat*)" Pick the word that goes in the blank." The student must discriminate among: *tat, cat, sat, cot*. The student reads the correct word, spells the correct word, and the instructor and student read the sentence together with the correct word. The student then writes the word on grid paper.

Treatment Fidelity and Attendance

Treatment Fidelity. Each of the nine instructors was observed for each treatment approximately nine times (Flex $M = 8.89$, $SD = 3.14$; Plain $M = 9.44$, $SD = 2.96$), and all children were formally observed by research staff at least once with their instructor (range of 1 to 5 per child), for a total of 168 observations conducted. Observations involved 20 yes/no items on a checklist, 15 for treatment content and 5 pertaining to general instructional behaviors. Across observations, Flex content fidelity averaged $M = 98\%$ ($SD = 2\%$) and Plain averaged $M = 99\%$ ($SD = 2\%$). General instructional behavior averaged $M = 94\%$ ($SD = 8\%$) for Flex and $M = 98\%$ ($SD = 2\%$) for Plain. Paired *t*-tests showed no significant differences between treatments on observation counts, content fidelity, or instructional behaviors (*p*s > .10).

Treatment Attendance. Instructors recorded weekly attendance for each child; children's attendance ranged from 15 to 24 days, with the Flex condition averaging 93% of the total days possible ($SD = 5\%$), and the Plain condition averaging 92% ($SD = 9\%$). Multilevel tests showed no evidence for a treatment difference (multilevel coefficient $p = .319$).

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.

Experimenter Measures. For each of the following 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 set of items, percent correct was calculated at pretest and posttest. As we report below, sample reliabilities were low at pretest due to floor effects (most children scored zero or close to zero on all pretest measures); however, by posttest, all measures exhibited better reliabilities.

Taught Letter Names and Sounds. For each test the examiner presented a printed sheet of 13 taught letters. Letters were arrayed in four rows of three to four items per row. Students first completed two practice items with untaught letters. The examiner directed the student to point and say the name (or sound) for each item, with 5 secs allowed for each item. If the student said the sound for the name (or vice versa), the examiner prompted the student, "Yes, that's the sound, what is the name." The examiner recorded 1 or 0 for each response, with a total score of 13. For letter names, sample internal consistencies (KR-20) were .58 and .87 at pretest and posttest, respectively; for letter sounds, sample internal consistencies were .29 and .86 at pretest and posttest, respectively.

Taught Letter Sound Writing. For each of the taught letters, the examiner dictated the taught sound for the student to write. The examiner 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 examiner 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 examiner 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 examiner prompted "This is a one letter sound." The examiner recorded 1 or 0 for each response, with a total score of 13. Sample reliabilities were .49 and .91 at pretest and posttest, respectively.

Word Reading. Students were asked to read 16 cvc words, all constructed with taught letters. The taught letters appeared initial, medial, and final word positions. The examiner first administered two practice items, 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 sheet in two columns and the examiner 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 examiner prompted once to "Say it fast" and allowed 5 sec for the student to read the word. The examiner recorded 1 or 0 for each response, with a total score of 16. Sample reliability could not be computed at pretest because all children scored zero; at posttest, reliability was .92.

Spelling. A set of 16 cvc words were used to test spelling. The items included taught letters only, and the letters appeared in initial, medial, and final positions in the words. The examiner dictated each word, and repeated the word once upon request, allowing 5 sec per word. The examiner recorded 1 or 0 for each response, with a total score of 16. Sample reliability could not be computed at pretest because all children scored zero; at posttest, reliability was .97.

Cognitive Flexibility. Cartwright's (2002) original sorting task and directions were adapted in this study for younger children with limited language skills to include three sets of picture cards used for one demonstration sort, and two test sorts. Materials for each sort were a set of 12 picture cards. The demonstration set included six fruits (three yellow and three red) and six flowers (three yellow and three red).The first test sort included six dogs (three gray and three brown) and six bugs (three gray and three brown). The second test sort included six shirts (three green and three orange) and six pants (three green and three orange). For the demonstration sort, the examiner named each picture, had the child repeat the word, and showed the child how to make two piles of fruits and flowers. After shuffling the cards the examiner showed the child how to make two piles of yellow and red things. Then the examiner showed how to sort the cards by two dimensions on the 2 x 2 matrix, explained the sort, gave the cards to the child and asked the child to try to sort on the grid. If the child was unable to sort correctly, the examiner demonstrated and explained the correct sort. For the two test sorts, the examiner handed the child the set of shuffled cards, and began timing when the child looked at the first card. The examiner named each picture as the child moved the card, and stopped timing when the child placed the last card. The examiner recorded whether the sort was correct, the type of errors, and the total sort time. For a correct sort the examiner asked the child to explain the sort, and recorded if the explanation was correct, and the type of errors.

The total score was 1 point for a correct sort and 2 points for a correct explanation; across the two tasks, a total of 6 points was possible. We computed the percent correct, unadjusted for time on task (but we note that controlling for time on task in the forthcoming analysis models did not substantively change the results). The bivariate correlation between set 1 (maximum of 3 points) and set 2 (maximum of 3 points) was .70 at pretest and .71 at posttest.

Analysis Plan

Multilevel modeling was used to analyze data while accounting for dependencies in child-level data due to classroom membership. Preliminary intercept-only analyses showed that intraclass correlations among pretests, posttests, and pre-post gains due to classroom membership (for pretest-posttest gains, *Range* = .00 to .10, *Median* = .06) were higher than those for instructor membership (for pretest-posttest gains, *Range* = .00 to .02, *Median* = .00). Given this, and also given that classrooms were likely to vary in literacy instruction time and curricula (whereas tutors were delivering heavily scripted lessons), we treated classrooms as Level 2 instead of tutors. (We also note there is insufficient data for cross-classified modeling; as such, it is possible that our models do not take into account tutor effects on the outcomes that are unrelated to other factors included in our models. This in turn may in slightly reduce our power for detecting treatment or covariate effects.)

To test our research questions, we modeled pre-post change as a function of treatment condition and EL status (given that we randomized treatments within classrooms within EL status), with students (Level 1, n = 68) nested within classrooms (Level 2, n = 22). Additionally, we included pretest receptive vocabulary (instead of individual experimenter pretest given the observed floor effects) as well as treatment attendance (given the variability observed across students) as covariates as well as their 2-way interactions with treatment to test for potential moderator effects. For ease of results interpretation, we effect-coded binary predictors (Flex = +1, Plain = -1; EL = +1, non-EL = -1), and standardized the other predictors into Z-scores. Models were estimated in *HLM7* using full information maximum likelihood and robust standard errors. Effect sizes were computed and reported for each predictor as follows: d = estimated coefficient / approximate pooled SD, where the approximate pooled $SD = SE$*sqrt(N).

Results

Descriptive statistics for each treatment condition (unadjusted for classroom membership) are shown in Table 1; zero-order correlations among variables included in analyses (also unadjusted for classroom membership) are provided in Table 2.

Pretest-Posttest Change. Table 3 presents our multilevel model results. Across all measures, the intercept (mean estimated pretest-posttest change) was significantly greater than zero, indicating that children across both conditions made substantial growth during the intervention, particularly in letter names (mean increase of 64% correct), sounds (74%), and letter sound writing (69%).

Treatment Effects. Main effects for treatment were observed for letter sound writing and spelling. On letter sound writing, the Flex treatment was predicted to have a 6% lower pretest-posttest gain than average (p = .015, d = -0.31), which can be translated as 12% lower than Plain. Similarly, Flex had 7% lower pretest-posttest gains than average on spelling by (p = .045, d = -0.25), which can be translated as 14% lower than Plain.

Covariates. Holding all else constant, receptive language was positively predictive of gains on the Color Card Sort measure only (p < .001, d = 0.42). Treatment attendance, on the other hand, was significantly predictive of gains in letter names (p = .031, d = 0.27) and letter sound writing (p = .037, d = 0.26), and exhibited trends in the same direction for letter sounds (p = .056, d = 0.24) and word reading (p = .091, d = 0.21). EL status, on the other hand, was not uniquely predictive of any pretest-posttest gains; this could be in part due to its correlation with receptive vocabulary (see again Table 2) and in part due to the relatively small proportion of EL children in the sample.

Moderators. The only significant treatment moderator was with receptive vocabulary on letter sound writing (p = .028, d = -0.28). Computing the model-predicted values revealed that Plain's advantage over Flex was higher for children with higher pretest receptive language (28% better gain) compared to peers with average receptive language (12% better gain). At the lower end, Flex had a small, albeit non-significant 6% advantage over Plain.

Discussion

In this experiment, children entering kindergarten with minimal alphabet knowledge were assigned to one of two versions of explicit instruction in GPCs and decoding which differed in how these phonics skills were taught. One condition embedded brief cognitive flexibility practice in the phonics instruction. All children gained in knowledge of taught mixed-size GPCs over a 6-

week intervention. Our findings for mixed-size GPC learning by at-risk kindergarteners support those from an earlier experiment (Vadasy & Sanders, 2020). While the value of teaching this mixed GPC content may not be initially apparent for this group of learners, it may have benefits in the near term when application of phonics skills in context becomes important: teaching high frequency GPCs allows the creation of more natural and engaging decodable texts in which children in can practice these correspondences, and at a stage in phonemic decoding development when these text supports may be most helpful (Juel & Roper/Schneider, 1985), and in the longer term when children apply these foundation skills to read more varied words. Children in the Plain condition made significantly greater gains in letter sound writing and spelling, suggesting that the focus in the Plain instruction on letter sounds and accuracy supported encoding.

Many children enter kindergarten with some exposure to letter names and sounds, and sufficient experience needed to recognize and retrieve accurate labels (names or sounds). In the fall of kindergarten when this study was conducted, we were able to recruit children screened with minimal alphabet knowledge, limited home literacy experiences, and limited exposure to classroom phonics instruction to allow us to examine growth in initial letter sound knowledge and phonemic decoding in a brief six-week intervention. Several limitations are noted. First, lack of a control group of untreated students limits ruling out whether treatments were better than classroom instruction, and prevents estimating the educational significance of growth observed for the treatments. A second limitation is the timing of a fall kindergarten intervention, when many children have not yet acquired classroom behaviors and familiarity with the language of instruction that even a few months later better support learning. A spring of kindergarten cohort was planned to compare the influence of timing on student learning. Planned spring follow-up of students in the current study to examine transfer of learning to decoding and spelling was cancelled due to COVID19. Consolidated learning, including fluency in retrieval of correspondences and application to decoding and orthographic mapping, may have been better detected at follow-up. A related limitation of a fall kindergarten intervention is the student floor effects on pretest reading measures. We were unable to address the question whether student entry levels of alphabet knowledge interacted with their pretest cognitive flexibility in response to the treatments. The timing of intervention in early kindergarten may also have limited our ability to detect treatment differences. That is, the Flex treatment, which included manipulation of letter sounds in initial and final word positions, may have been too difficult for beginning leaner

s who were establishing basic accuracy in taught sounds. Finally, added pretest and posttest of all letter names and sounds would have allowed us to examine letter learning in the classroom and learning transfer.

Building upon earlier research, in this study we found that young kindergarteners with little knowledge of the alphabet learned both high frequency single and two-letter GPCs and applied that learning to letter sound writing and spelling. The cognitive flexibility training we embedded into the Flex learning activities did not have significant benefits compared to the Plain explicit phonics instruction. Children's receptive vocabulary significantly predicted their card sort performance, which reflects the difficulty of the task for these young learners with lower language skill. Card sort task performance may have been confounded with difficulty understanding the spoken instructions, as well as difficulty of the task at ages when executive function is developing (Lucenet & Blaye, 2014; Taboada Barber et al., 2020). As in similar early reading intervention studies with at-risk students, treatment attendance predicted several outcomes (Lovett et al., 2017). Findings suggest that explicit phonics instruction that *initially* introduces struggling kindergarteners to letter-sound correspondences and phonemic decoding (often the literacy focus in U.S. schools later in kindergarten) should have a strong focus on learning the GPCs to accuracy, with intensive guided practice (Rosenshine, 2012), and warrant selecting GPCs for instruction based on frequency. Although the Flex practice activities were brief, and were not observed to distract children from this learning, they did not support learning in this young sample, either in providing an advantage on the reading or the cognitive flexibility outcomes. The Flex tasks may not have been designed to generalize to the reading outcomes, may have been introduced too early in phonics instruction, or children may have required an established foundation in accurate alphabet knowledge to benefit from flexibility practice. These remain questions for future investigations on how to better teach phonics skills for students who struggle the most with essential early literacy learning.

References

Al Otaiba, S., & Fuchs, D. (2006). Who are the young children for whom best practices in reading are ineffective?: An experimental and longitudinal study. *Journal of Learning Disabilities, 39*, 441-431.

Apel, K. (2009). The acquisition of mental orthographic representations for reading and spelling development. *Communication Disorders Quarterly*, *31*, 42-52.

Bierman, K. L., Nix, R. L., Greenberg, M. T., Blair, C., & Domitrovich, C. E. (2008). Executive functions and school readiness intervention: impact, moderation, and mediation in the Head Start REDI program. *Developmental Psychopathology*, *20*, 821-843. http://doi.org/10.1017/S0954579408000394

Bowers, P. G., Sunseth, K., & Golden, J. (1999). The route between rapid naming and reading progress. *Scientific Studies of Reading*, *3*, 31-53. http://doi.org/10.1207/s1532799xssr0301-2

Bowyer-Crane, C., Snowling, M. J., Duff, F. J., Fieldsend, E., Carroll, J. M., Miles, J., Gotz, K., & Hulme, C. (2008). Improving early language and literacy skills: differential effects of an oral language versus a phonology with reading intervention. *Journal of Child Psychiatry and Psychology*, *49*, 422-432. http://doi.org/10.1111/j.1469-7610.2007.01849x

Brady, S. A. (2011). Efficacy of phonics teaching for reading outcomes: Indications from post-NRP research. In S.A. Brady, D. Braze, & C.A. Fowler (Eds.), *Explaining individual differences in reading: Theory and evidence* (pp. 69-96). New York: Psychology Press.

Carnine, D., Silbert, J., & Kame'enui, E. J. (1997). *Direct instruction reading* (3rd ed.). Columbus, OH: Merrill.

Cartwright, K. B. (2006). Fostering flexibility and comprehension in elementary students. *The Reading Teacher*, *59*, 628-634.

Cartwright, K. B. (2002). Cognitive development and reading: the relation of reading-specific multiple classification skill to reading comprehension in elementary school children. *Journal of Educational Psychology*, *94,* 56-63.

Cartwright, K. B., Coppage, E. A., Lane, A. B., Singleton, T., Marshall, T. R., & Bentivegna, C. (2017). Cognitive flexibility deficits in children with specific reading comprehension difficulties. *Contemporary Educational Psychology*, *50*, 33-44.

Cartwright, K. B., Isaac, M. C., & Dandy, K. L. (2006). The development of reading-specific representational flexibility: A cross-sectional comparison of second graders and college students. In A. V. Mittel (Ed.), *Focus on educational psychology* (pp. 173-194). New York: Nova Science.

Cartwright, K. B., Marshall, T. R., Dandy, K. L., & Isaac, M. C. (2010). The development of graphophonological-semantic cognitive flexibility and its contribution to reading comprehension in beginning readers. *Journal of Cognition and Development, 11*, 61-85.

Cartwright, K. B., Bock, A. M., Clause, J. H., Coppage August, E. A., Saunders, H. G., & Schmidt, K. J. (2020). Near- and far-transfer effects of an executive function intervention for 2nd to 5th-grade struggling readers. *Cognitive Development*. Advance online publication. https://doi.org/10.1016/j.cogdev.2020.100932

Castles, A., Holmes, V. M., Neath, J., & Kinoshita, S. (2003). How does orthographic knowledge influence performance on phonological awareness tasks? *The Quarterly Journal of Experimental Psychology*, *56*, 445-467.

Castles, A., Rastle, K., & Nation, K. (2018). Ending the reading wars: Reading acquisition from novice to expert. *Psychological Science in the Public Interest*, *19*, 5-51.

Chard, D. J., & Osborn, J. (1999). Phonics and word recognition instruction in early reading programs: Guidelines for accessibility. *Learning Disabilities Research & Practice*, *14*, 107-117.

Compton, D. L., Miller, A. C., Elleman, A. M., & Steacy, L. M. (2014). Have we forsaken reading theory in the name of "quick fix" interventions for children with reading disability? *Scientific Studies of Reading*, *18*, 55-73.

Cole, P., Duncan, L. G., & Blaye, A. (2014). Cognitive flexibility predicts early reading skills. *Frontiers in Psychology*, *5*, 1-8. http://doi.org/10.3389/fpsyg.2014.00565

Conrad, N. J., Harris, N., & Williams, J. (2013). Individual differences in children's literacy development: the contribution of orthographic knowledge. *Reading and Writing: An Interdisciplinary Journal*, *26*, 1223-1239.

Conrad, N. J., & Levy, B. A. (2011). Training letter and orthographic pattern recognition in children with slow naming speed. *Reading and Writing: An Interdisciplinary Journal*, *24*, 91-115.

Deacon, S. H., Conrad, N., & Pacton, S. (2008). A statistical learning perspective on children's learning about graphotactic and morphological regularities in spelling. *Canadian Psychology*, *49*, 118-124.

Dehaene, S., Cohen, L., Sigman, M., & Vinckier, F. (2005). The neural code for written words: a proposal. *Trends in Cognitive Science*, *9*, 335-341. http://doi.org/10.1016/J.tics.2005.05.004

Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). The early years: Preschool program improves cognitive control. *Science, 318*, 1387-1388. http://dx.doi.org/10.1126/science.1151148

Dias, N. M., & Seabra, A. G. (2017). Intervention for executive functions development in early elementary school children: effects on learning and behaviour, and follow-up maintenance. *Educational Psychology*, *37*, 468-486. http://doi.org/10.1080/01443410.2016.1214686

Dowsett, S. M., & Livesey, D. J. (2000). The development of inhibitory control in preschool children: Effects of "executive skills" training. *Developmental Psychology*, *36*, 161-174. http://dx.doi.org/a0.1002/(SICI)1098-2302(200003)

Dunn, L. M., & Dunn, D. M. (2006). *Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4)*. Bloomington, MN: Pearson.

Ehri, L. C. (2014). Orthographic mapping in the acquisition of sight word reading: Spelling, memory, and vocabulary learning. *Scientific Studies of Reading*, *18*, 5-21.

Ehri, L. C. (2005). Development of sight word reading: Phases and findings. In M. Snowling & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 135-154). Malden, MA: Blackwell.

Ehri, L. C., Satlow, E., & Gaskins, I. (2009). Grapho-phonemic enrichment strengthens keyword analogy instruction for struggling young readers. *Reading and Writing Quarterly*, *25*, 162-191.

Foorman, B. R., Francis, D. J., Fletcher, J. M., Schatschneider, C., & Mehta, P. (1998). The role of instruction in learning to read: Preventing reading failure in at-risk children. *Journal of Educational Psychology*, *90*, 37-55. http://doi.org/10.1037/0022-0663.90.1.37

Fuchs, D., Hendricks, E., Walsh, M. E., Fuchs, L. S., Gilbert, J. K., Zhang Tracy, W., ... Peng, P. (2018). Evaluating a multidimensional reading comprehension program and reconsidering the lowly reputation of tests of near-transfer. *Learning Disabilities Research & Practice*, *33*, 11-23. http://doi.org/10.1111/ldrp.12162

Fuhs, M. W., Nesbitt, K. T., Farran, D. C., & Dong, N. (2014). Longitudinal associations between executive functioning and academic skills across content areas. *Developmental Psychology*, *50*, 1698-1709.

Grainger, J., & Ziegler, J. C. (2011). A dual-route to orthographic processing. *Frontiers in Psychology*, *2*, Article 54. https://doi.org/10.3389/fpsyg.2011.00054

Guajardo, N. R., & Cartwright, K. B. (2016). The contribution of theory of mind, counterfactual reasoning, and executive function to pre-readers' language comprehension and later reading awareness and comprehension in elementary school. *Journal of Experimental Child Psychology*, *144*, 27-45.

Jones, C. D., & Reutzel, D. R. (2012). Enhanced alphabet knowledge instruction: Exploring a change of frequency, focus, and distributed cycles of review. *Reading Psychology*, *33*, 448-464. http://dx.doi.org/10.1080/02702711.2010.545260

Juel, C., & Roper-Schneider, D., (1985). The influence of basal readers on first grade reading. *Reading Research Quarterly*, *20*, 134-152.

Karbach, J., & Kray, J. (2009). How useful is executive control training? Age differences in near and far transfer of task-switching training. *Developmental Science*, *12*, 978-990. http://dx.doi.org/10.1111/j.1467-7687.2009.00846.x

Kessler, B., Pollo, T. C., & Treiman, R. (2012). Frequency analyses of phonological spellings as predictors of success in conventional spelling. *Journal of Learning Disabilities*, *46*, 252-259. https://doi.org/10.1177/0022219412449440

Kieffer, M. J., & Christodoulou, J. A. (2020). Automaticity and control: How do executive functions and reading fluency interact in predicting reading comprehension? *Reading Research Quarterly*, *55*, 147-166. http://doi.org/10.1002/rrq.289

Kievit, R. A., Hofman, A. D., & Nation, K. (2019). Mutualistic coupling between vocabulary and reasoning in young children: A replication and extension of the study by Kievit et al. (2017). *Psychological Science*, *30*, 1245-1252. http://doi.org/10.1177/0956797619841265

Kilpatrick, D. A. (2015). *Essentials of assessing, preventing, and overcoming reading difficulties*. Hoboken, NJ: John Wiley & Sons.

Lovett, M. W., Fritters, J. C., Wolf, M., Steinbach, K. A., Sevcik, R. A., & Morris, R. D. (2017). Early intervention for children at risk for reading disabilities: The impact of grade at intervention and individual differences on intervention outcomes. *Journal of Educational Psychology*, *109*, 889-914. http://doi.org/10.1037/edu0000181

Lucenet, J., & Blaye, A. (2014). Age-related changes in the temporal dynamics of executive control: a study in 5- and 6-year-old children. *Frontiers in Psychology*, *5*, Article 831. https://doi.org/10.3389/fpsg.2014.00831

Martin-Chang, S., Ouellette, G., & Bond, L. (2017). Differential effects of context and feedback on orthographic learning: How good is good enough? *Scientific Studies of Reading*, *21*, 17-30. http://dx.doi,org/10.1080/10888438.2016.1263993

Mesmer, H. A. E. (1999). Scaffolding a crucial transition using text with some decodability. *The Reading Teacher*, *53*, 130-142.

Neuman, S. B. (2006). N is for nonsensical: Low-income preschool children need content-rich instruction, not drill in procedural skills. *Educational Leadership*, *64*, 28-31.

Ober, T. M., Brooks, P. J., Homer, B. D., & Rindskopf, D. (2020). Executive function and decoding in children and adolescents: a meta-analytic investigation. *Educational Psychology Review*. Advance online publication. https://doi.org/10.1007/s10648-020-09526-0

Peng, P., & Fuchs, D. (2017). A randomized control trial of working memory training with and without strategy instruction: Effects on young children's working memory and comprehension. *Journal of Learning Disabilities*, *50*, 62-80. https://doi.org/10.1177/0022219415594609

Peng, P., Fuchs, D., Fuchs, L., Elleman, A.M., Kearns, D.M., Gilbert, J., ... Patton, S. (2019). A longitudinal analysis of the trajectories and predictors of word reading and reading comprehension development among at-risk readers. *Journal of Learning Disabilities*, *52*, 195-208. https://doi.org/10.1177/0022219418809080

Peng, P., & Goodrich, M. (2020). The cognitive element model of reading instruction. *Reading Research Quarterly*. Advance online publication. http://doi.org/10.1002/RRQ.336.

Peng, P., & Kievit, R. (2020). The development of academic achievement and cognitive abilities: A bidirectional perspective. *Child Development Perspectives*, *14*, 15-20. https://doi.org/10.1111/cdep.12352

Perfetti, C. A. (1992). The representation problem in reading acquisition. In P. B. Gough, L. C. Ehri, & R. Treiman (Eds.), *Reading acquisition* (pp. 145-174). Hillsdale, NJ: Erlbaum.

Perruchet, P., & Pacton, S. (2006). Implicit learning and statistical learning: one phenomenon, two approaches. *Trends in Cognitive Science*, *10*, 233-238. https:/doi.org/10.1016/j.tics.2006.03.006

Rosenshine, B. (2012). Principles of instruction: Research-based strategies that all teachers should know. *American Educator, Spring*, 12-39.

Rothe, J., Schulte-Korne, G., & Ise, E. (2014). Does sensitivity to orthographic regularities influence reading and spelling acquisition: A 1-year prospective study. *Reading and Writing: An Interdisciplinary Journal*, *27*, 1141-1161.

Seidenberg, M. S. (2013). The science of reading and its educational implications. *Language Learning and Development*, *9,* 331-360. http://doi.org/10.1080/15475441.2013.812017

Seidenberg, M. S., Borkenhagen, M. C., & Kearns, D. M. (2020). Lost in translation? Challenges in connecting reading science and educational practice. *Reading Research Quarterly*, *55*, S119-S130. http://doi.org/10.1002/rrq.341

Siegelman, N., Rueckl, J. G., Steacy, L. M., Frost, S. J., van den Bunt, M., Zevin, J. D., Seidenberg, M. S., Pugh, K. R., Compton, D. L., & Morris, R. D. (2020). Individual differences in learning the regularities between orthographic phonology and semantics predict early reading skills. *Journal of Memory and Language*, *114*. Advance online publication. https://doi.org/10/1016/j.jml.2020.104145

Share, D. L. (2004). Orthographic learning at a glance: on the time course and developmental onset of self-teaching. *Journal of Experimental Child Psychology*, *87*, 267-298.

Solity, J., & Vousden, J. (2009). Real books vs reading schemes: a new perspective from instructional psychology. *Educational Psychology*, *29*, 469-511. http://doi.org/10.1080/01443410903103657

Stuebing, K. K., Barth, A. E., Cirino, P. T., Francis, D. J., & Fletcher, J. M. (2008). A response to recent reanalyses of the National Reading Panel report: Effects of systematic phonics instruction are practically significant. *Journal of Educational Psychology*, *100*, 123-134. http://doi.org/ 10.1037/0022-0663.100.1.123

Swanson, H. L., & O'Connor, R. E. (2009). The role of working memory and fluency practice on the reading comprehension of students who are dysfluent readers. *Journal of Learning Disabilities*, *42*, 548-574. https://doi.org/10.1177/0022219409338742

Taboada Barber, A., Cartwright, K. B., Stapleton, L., Lutz Klauda, S., Archer, C., & Smith, P. (2020). Direct and indirect effects of executive functions, reading engagement, and higher order strategic processes in the reading comprehension of dual language learners and English monolinguals. *Contemporary Educational Psychology*. Advance online publication. https://doi.org/10.1016/j.cedpsych.2020.101848

Torgesen, J. K. (2000). Individual differences in response to early interventions in reading: The lingering problem of treatment resisters. *Learning Disabilities Research and Practice, 15*, 55-64.

Treiman, R., & Cassar, M. (1997). Spelling acquisition in English. In C.A. Perfetti, L. Rieben, & M. Fayol (Eds.), *Learning to spell: Research, theory, and practice across languages* (pp. 61-80). Mahwah, NJ: Erlbaum.

Vadasy, P. F., & Sanders, E. A. (2020). Introducing grapheme-phoneme correspondences (GPCs): exploring rate and complexity in phonics instruction for kindergarteners with limited literacy skills. *Reading and Writing: An Interdisciplinary Journal.* doi:10.1007/s11145-020-10064-y

Vadasy, P. F., & Sanders, E., A. (2013). Two-year follow-up of a code-oriented intervention for lower-skilled first-graders: The influence of language status and word reading skills on third-grade literacy outcomes. *Reading and Writing: An Interdisciplinary Journal, 26*, 821-843.

Vadasy, P.F., & Sanders, E.A. (2012). Two-year follow-up of a kindergarten phonics intervention for English learners and native English speakers: Contextualizing treatment impacts by classroom literacy instruction. *Journal of Educational Psychology, 104, 987-100.* doi:1037/a0028163

Vadasy, P. F., & Sanders, E. A. (2011). Efficacy of supplemental phonics-based instruction for low-skilled first graders: How language minority status and pretest characteristics moderate treatment response. *Scientific Studies of Reading, 15*, 471-497. doi:10.1080/10888438.2010.501091

Vadasy, P. F., & Sanders, E. A. (2010). Efficacy of supplemental phonics-based instruction for low-skilled kindergarteners in the context of language minority status and classroom phonics instruction. *Journal of Educational Psychology, 102*(4), 786–803.

Vadasy, P. F., Sanders, E. A., & Abbott, R. D. (2008). Effects of supplemental early reading intervention at 2-year follow up: Reading skill growth patterns and predictors. *Scientific Studies of Reading, 12*(1), 51-89.

Vadasy, P. F., Sanders, E. A., & Tudor, S. (2007). Effectiveness of paraeducator-supplemented individual instruction: Beyond basic decoding skills*.* *Journal of Learning Disabilities, 40*(6), 508-525.

Vadasy, P. F., Sanders, E. A., & Peyton, J. A. (2006). Code-oriented instruction for kindergarten students at risk for reading difficulties: A randomized field trial with paraeducator implementers. *Journal of Educational Psychology*, *98*(3), 508-528.

Vadasy, P. F., Sanders, E. A., & Peyton, J. A. (2005). Relative effectiveness of reading practice or word-level instruction in supplemental tutoring: How text matters. *Journal of Learning Disabilities*, *38*(4), *364-380.*

van de Sande, E., Segers, E., & Verhoeven, L. (2013). How phonological awareness mediates the relation between children's self-control and word decoding. *Learning and Individual Differences*, *26*, 112-118. http://dx.doi.org/10.1016/j.lindif.2013.05.002

van den Broeck, W., & Geudens, A. (2012). Old and new ways to study characteristics of reading disability: The case of the nonword-reading deficit. *Cognitive Psychology*, *65*, 414-456. http://dx.doi.org/10.1016/j.cogpsych.2012.06.003

Vellutino, F. R., Fletcher, J. M., Snowling, M. J., & Scanlon, D. M. (2004). Specific reading disability (dyslexia): What have we learned in the past four decades? *Journal of Child Psychology and Psychiatry*, *45*, 2-40.

Vitiello, V. E., Greenfield, D. B., Munis, P., & George, J. (2011). Cognitive flexibility, approaches to learning, and academic school readiness in Head Start preschool children. *Early Education and Development*, *22*, 388-410.

Welsh, J. A., Nix, R. L., Blair, C., Bierman, K. L., & Nelson, K. E. (2010). The development of cognitive skills and gains in academic school readiness for children from low-income families. *Journal of Educational Psychology*, *102*, 43-53.

Wolter, J. A., & Apel, K. (2010). Initial acquisition of mental graphemic representations in children with language impairment. *Journal of Speech, Language, and Hearing Research*, *53*, 179-195. http://doi.org/10.1044/1092-4388(2009/07-0130)

Wright, D. M., & Ehri, L. C. (2007). Beginners remember orthography when they learn to read words: The case of doubled letters. *Applied Psycholinguistics*, *28*, 115-134.

Ziegler, J. C., & Goswami, U. (2005). Reading acquisition, developmental dyslexia, and skilled reading across languages: A psycholinguistic grain size theory. *Psychological Bulletin*, *131*, 3-29.

Table 1

Observed (Unadjusted) Sample Descriptive Statistics

	Flex (*n* = 33)						Plain (*n* = 35)					
	Pretest		Posttest		Gain		Pretest		Posttest		Gain	
Measure	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
Receptive Vocab	82.85	(23.27)					82.20	(21.20)				
Letter Names	10%	(10%)	72%	(27%)	63%	(26%)	12%	(13%)	77%	(26%)	65%	(23%)
Letter Sounds	2%	(4%)	70%	(28%)	68%	(28%)	3%	(6%)	80%	(22%)	77%	(22%)
Letter Sound Writing	1%	(4%)	64%	(30%)	63%	(30%)	2%	(6%)	70%	(33%)	68%	(32%)
Word Reading	0%	(0%)	11%	(19%)	11%	(19%)	0%	(0%)	20%	(28%)	20%	(28%)
Spelling	0%	(0%)	9%	(22%)	9%	(22%)	0%	(0%)	19%	(33%)	19%	(33%)
Color Card Sort	5%	(14%)	21%	(33%)	17%	(32%)	7%	(16%)	27%	(34%)	20%	(36%)

Note. Receptive Vocab = PPTV-4 standard score, all other measures are experimenter developed measures reported in percent correct; letter names, letter sounds, and letter sound writing have a maximum of 13 points; word reading and word spelling have a maximum of 16 points; color card sort has a maximum of 6 points. Gain = change from pretest to posttest.

Table 2

Observed (Unadjusted) Zero-Order Correlations for Variables included in Models

Measure	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Treatment (1 = Flex)	--									
2. EL Status (1 = Yes)	.09	--								
3. Receptive Vocab pretest	.02	-.22	--							
4. Treatment Attendance	.08	.01	.08	--						
5. Letter Names Gain	-.05	.12	-.11	.23	--					
6. Letter Sounds Gain	-.19	.12	-.12	.24	**.72**	--				
7. Letter Sound Writing Gain	-.08	.16	.09	.16	**.61**	**.71**	--			
8. Word Reading Gain	-.18	-.12	-.03	.15	**.31**	**.41**	**.47**	--		
9. Spelling Gain	-.17	-.09	-.08	.04	**.27**	**.37**	**.39**	**.79**	--	
10. Color Card Sort Gain	-.05	-.10	**.34**	-.02	.02	.19	.12	.15	.17	--

Note. *N* = 68 children across 22 teachers, with 33 in Flex condition and 35 in Plain condition; EL = English learner; Receptive Vocab = PPTV-4 standard score; Treatment Attendance in percent of total possible days; all other measures are experimenter developed measures reported in percent correct; letter names, letter sounds, and letter sound writing have a maximum of 13 points; word reading and word spelling have a maximum of 16 points; color card sort has a maximum of 6 points. Gain = change from pretest to posttest. Bolded correlations are significant at $p < .05$.

Table 3

Multilevel Model Fixed Effects Results Predicting Pre-Post Change

	Letter Names		Letter Sounds		Ltr Sound Wrt		Word Reading		Spelling		Col Card Sort	
Fixed Effect	*Coeff*	*d*	*Coeff*	*d*	*Coeff*	*D*	*Coeff*	*d*	*Coeff*	*d*	*Coeff*	*d*
Intercept (Mean Gain)	0.64***		0.74***		0.69***		0.13***		0.12**		0.18***	
Treatment (+1 = Flex)	0.00	.01	-0.05	-.18	-0.06*	-.20	-0.03	-.31	-0.07*	-.25	0.02	.05
EL Status (+1 = Yes)	0.01	.05	0.03	.13	0.06	.22	-0.04	.20	-0.03	-.10	0.00	-.02
Receptive Vocab (*Z*)	-0.02	-.10	-0.03	-.15	0.02	.09	-0.01	.10	-0.03	-.12	0.12***	.42
Treatment Attend (*Z*)	0.08*	.27	0.07	.24	0.09*	.30	0.04	.26	0.00	.02	-0.02	-.07
Treatment*EL	0.03	.11	0.01	.06	-0.03	-.10	0.03	-.12	-0.04	-.11	0.05	.19
Treatment*RV	-0.05	-.24	-0.03	-.15	-0.08*	-.30	-0.02	-.28	-0.03	-.11	0.04	.12
Treatment*Attend	0.03	.09	0.01	.02	0.06	.21	0.00	.16	-0.03	-.15	-0.01	-.02

Note. *N* = 68 children across 22 teachers, with 33 in Flex condition and 35 in Plain condition. Ltr Sound Wrt = Letter Sound Writing; Col Card Sort = Color Card Sort. EL = English learner; Receptive Vocab (RV) = PPTV-4 standard score; Treatment Attend = treatment attendance in percent of total possible days; all other measures are experimenter developed measures reported in percent correct; letter names, letter sounds, and letter sound writing have a maximum of 13 points; word reading and word spelling have a maximum of 16 points; color card sort has a maximum of 6 points. Gain = change from pretest to posttest. All binary predictors effect-coded; all other predictors standardized (*Z*).