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Developing Early Literacy Skills: A Meta-Analysis of Alphabet Learning and Instruction

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Abstract

Alphabet knowledge is a hallmark of early literacy and facilitating its development has become a primary objective of pre-school instruction and intervention. However, little agreement exists about how to promote the development of alphabet knowledge effectively. A meta-analysis of the effects of instruction on alphabet outcomes demonstrated that instructional impacts differed by type of alphabet outcome examined and content of instruction provided. School-based instruction yielded larger effects than home-based instruction; small-group instruction yielded larger effects than individual tutoring programs. We found minimal evidence of transfer of alphabet instruction to early phonological, reading, or spelling skills. Implications for research and practice are discussed.

In the field of early literacy, alphabet knowledge refers to children's familiarity with letter forms, names, and corresponding sounds, as measured by recognition, production, and writing tasks. Together, such alphabet knowledge represents an important component of emergent literacy (Whitehurst & Lonigan, 1998). Children's knowledge of letter names and sounds is the best predictor of their later reading and spelling abilities (Hammill, 2004; Scarborough, 1998; Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004). Letter name and letter sound knowledge predict subsequent literacy skills independently of other important predictors including phonological awareness and oral language (Burgess & Lonigan, 1998; McBride-Chang, 1999; Wagner, Torgesen, & Rashotte, 1994). Preschool and kindergarten students with poor knowledge of letter names and sounds are more likely to struggle with learning to read and be classified as having reading disabilities (Gallagher, Frith, & Snowling, 2000; O'Connor & Jenkins, 1999; Torppa, Poikkeus, Laakso, Eklund, & Lyytinen, 2006). These children tend to fall further behind their peers in reading acquisition, leading to gaps in spelling, reading fluency, vocabulary, and comprehension skills (Stanovich, 1986; Torgesen, 2002).

For these reasons, alphabet knowledge has become an important learning goal for young children. The National Association for the Education of Young Children (NAEYC) recognizes development of the alphabetic principle as a goal for the preschool years and proficiency in letter discrimination, letter naming, and letter–sound correspondences are expected during the kindergarten year (NAEYC, 1998). Standards for Head Start (U.S. Department of Health and Human Services & Administration for Children and Families, 2003) require children to demonstrate awareness of letters as individual symbols and the

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capability to identify at least 10 letters by name. Both the Early Reading First and Reading First programs set explicit goals for increasing letter knowledge and letter–sound correspondences (U.S. Department of Education, 2002; 2003). Finally, many state curriculum frameworks, as required by the No Child Left Behind Act of 2002, include letter name learning, basic sound knowledge, and letter writing in their literacy standards for prekindergarten and kindergarten students (e.g., Florida Department of Education, n.d.; Massachusetts Department of Education, 2001).

Despite these initiatives, relatively little is known about the impact of early instruction on the development of alphabet knowledge. This fact is especially troublesome as large numbers of children continue to enter kindergarten knowing less than half of the letter names and fewer letter sounds (U.S. Department of Health and Human Services & Administration for Children and Families, 2005, 2006). Approaches to alphabet teaching vary greatly, as there has been disagreement about the appropriateness of early literacy instruction and about what constitutes effective instruction (Bredekamp, 1987; Dickinson, 2002; Elkind & Whitehurst, 2001; Foulin, 2005; Justice, Pence, Bowles, & Wiggins, 2006). The present study synthesized the research literature on the effects of alphabet instruction on both alphabet knowledge and other emergent literacy outcomes. We examined potential moderators of these effects, including factors related to sample and instructional characteristics. We also examined whether effect sizes were affected by publication bias or methodological issues related to study quality.

NELP and the Impact of Alphabet Knowledge Instruction

Despite its importance, alphabet knowledge often is overlooked as a specific outcome of interest compared with other aspects of literacy instruction such as phonological awareness or reading per se (see, e.g., Bus & van IJzendoorn, 1999; National Institute of Child Health and Human Development [NICHD], 2000; Wagner, 1988). An exception is the recent synthesis conducted by the National Early Literacy Panel (NELP), charged with identifying “interventions, parenting activities, and instructional practices that promote the development of…early literacy skills” for children from birth to age 5 (NELP, 2008, p. vi). Alphabet knowledge comprised one of the emergent literacy skill outcomes investigated by the Panel. In synthesizing the results of 24 code-focused early childhood intervention studies meeting inclusion criteria, the NELP study found an overall average effect size of 0.38 (95% confidence interval = 0.18 to 0.58) on alphabet knowledge outcomes. Effects on alphabet learning were found to vary based on demographic characteristics (child age, ethnicity, extent of literacy knowledge, population density of the location in which the study was conducted) as well as whether letter instruction was combined with training in phonological awareness. Other types of interventions investigated by the Panel (e.g., shared reading, general preschool/kindergarten programs) showed no reliable impact on children’s alphabet knowledge.

The NELP (2008) study, however, was limited in four important ways.[1] First, the criteria used to select studies for inclusion in the meta-analysis narrowed its scope considerably. The review included only studies published in peer-reviewed journals, a decision that promotes publication bias, widely recognized as a threat to the validity of meta-analyses (Cooper & Hedges, 1994). *Publication bias* refers to the problem of selective publication, in which the decision to publish a study is influenced by its results (e.g., the statistical significance of findings; Rosenthal, 1979). When it occurs, the effect sizes of meta-analyses that include only published studies are positively biased (i.e., larger than the true effect size). The review

[1]The NELP review included separate syntheses of both the correlational and intervention literature in the area of early literacy; the limitations addressed in the current study refer to the latter. Additional information pertaining to NELP is available at www.nifl.gov.

also excluded studies involving participants older than kindergarten age, despite the fact that alphabet instruction, particularly letter sound instruction, may continue into first and later grades, particularly for at-risk students.

Second, as alphabet knowledge was one of many outcomes examined in the NELP study, the impact of instruction on this outcome was not examined in great detail. The NELP study did not distinguish between various alphabet outcomes such as letter name knowledge, letter sound knowledge, or letter writing, instead collapsing all alphabet outcomes into a single construct and prohibiting disambiguation of differential effects across alphabetic domains.

The overall effect size reported in the NELP report also amalgamated across all types of code-focused early childhood interventions (e.g., interventions that did and did not provide alphabet instruction) and did not thoroughly investigate the impact of specific instructional components on alphabet knowledge outcomes despite evidence that the focus of instruction may be particularly noteworthy. The teaching of specific alphabet skills, for example, may be important in facilitating alphabet knowledge growth. A growing body of research demonstrates reciprocal relations between letter name and sound knowledge and suggests that instruction in letter names may facilitate letter sound learning for those letters whose names also include their sounds (e.g., the /b/ at the beginning of the letter name *B* or the /f/ at the end of the letter name *F*), with children using the information contained in the letter names to derive or cue corresponding sounds (e.g., Evans, Bell, Shaw, Moretti, & Page, 2006; Levin, Shatil-Carmon, & Asif-Rave, 2006; McBride-Chang, 1999; Share, 2004; Treiman, Tincoff, Rodriguez, Mouzaki, & Francis, 1998; Treiman, Weatherston, & Berch, 1994). Considerable evidence also suggests reciprocal relations between phonological skills and alphabet knowledge development (Burgess & Lonigan, 1998; Lonigan, Burgess, & Anthony, 2000; McBride-Chang, 1999; Wagner et al., 1994), including potential benefits of phonological training on alphabet skills (Ball & Blachman, 1991).

Although specific alphabet and phonological awareness instructional foci may thus have an impact on alphabet learning, consideration of phonological training represented the sole instructional factor investigated by the NELP study. Specifically, the NELP study disaggregated studies according to whether interventions included phonological awareness training only (effect size [*ES*] = 0.04), phonological awareness training plus alphabet training (*ES* = 0.37), or phonological awareness training plus phonics training (*ES* = 0.57).[2] Effects were not disaggregated for the type of alphabet training provided (i.e., letter names, letter sounds), nor was the effect of pure alphabet instruction studied with respect to alphabet knowledge outcomes as no studies were found to fit this category.

Studies with alphabet training as the lone instructional focus are especially interesting as they may speak to the causal direction of relations between alphabet knowledge and reading and spelling skills, which has not been well established (Ehri, 1983; Foulin, 2005). Although some theorists place great emphasis on letter learning as requisite for later literacy development (largely based on high correlations among these skills; e.g., Adams, 1990; Ehri, 1998), others have questioned the necessity of such knowledge, and letter name knowledge in particular, on reading and spelling skill acquisition (Groff, 1984; McGuinness, 2004; Venezky, 1975, 1979). It is also possible that reciprocal relations exist among these skills, as seen in the phonological awareness literature (Burgess & Lonigan, 1998; Wagner et al., 1994). Overall, because alphabet acquisition was only a single aspect of a much broader study, the NELP results were unable to address a number of important questions concerning the impact of instruction on alphabet and other emergent literacy outcomes.

[2]The NELP study also disaggregated those studies including phonological awareness training by the level of linguistic complexity (subphonemic, phonemic, both) and cognitive skill (analysis, synthesis, both) targeted.

Third and finally, the NELP review covered only those articles available through March 2003 (C. Schatschneider, personal communication, March 2, 2009). Additional published and unpublished studies have become available since that time.

The Present Study

The present meta-analysis expands the NELP review in four ways. First, we included all studies providing alphabet training and assessing alphabet outcomes through November 2006. Second, we disambiguated effects for five discrete alphabet outcomes (letter name knowledge, letter sound knowledge, letter name fluency, letter sound fluency, and letter writing). Third, we attended to the specific targets of the alphabet instruction provided, whether training in letter names, letter sounds, or both. Fourth and finally, we differentiated between studies providing multicomponential and alphabet-only instruction (i.e., those targeting alphabet knowledge in addition to other literacy domains versus solely targeting alphabet skills). The latter allowed us to examine (a) the effects of including alphabet training as one dimension of more general literacy instruction, (b) potential facilitative effects of phonological training on alphabet knowledge development, and (c) causal relations between alphabet instruction and emergent literacy skill acquisition (including alphabet knowledge development) through synthesis of studies in which only children's alphabet knowledge was manipulated.

We anticipated significant, positive effects of instruction on children's alphabet knowledge. Overall, we anticipated slightly larger effect sizes than those reported by NELP, as all studies in the present synthesis included alphabet instruction. We expected our results to be most consistent with those of NELP when considering studies providing multicomponential instruction, given the NELP study's reliance on such studies, as opposed to those providing only alphabet instruction. With respect to instructional foci, we expected to see larger effects in instances requiring minimal transfer (e.g., letter name instruction on letter name knowledge), to see transfer from letter name instruction to letter sound learning (as based on the extant literature), and to see benefits of combining alphabet and phonological instruction (as found by NELP). Finally, we expected significant, positive effects of alphabet instruction on phonological awareness, reading, and spelling outcomes.

Method

Search and Selection Procedure

An extensive literature search sought to identify published and unpublished studies measuring the effect of instruction on alphabet outcomes. The PsycInfo and ERIC databases were searched, using the earliest possible start date through November 2006. The past 10 years of Dissertation Abstracts International were also searched via ProQuest. Titles, abstracts, and keywords were searched for the word *alphabet* or derivations thereof or the string *letter* knowledge*, which allowed for inclusion of additional phrases such as *letter sound knowledge*, *letter–sound correspondence knowledge*, and so forth. The initial set of 4,686 references was narrowed via the following four selection criteria: (1) study of an instructional program or intervention designed to foster literacy skills in an alphabetic language, (2) sample that included children (i.e., participants were less than 18 years of age), (3) use of a quantitative research design, either experimental or quasi-experimental, allowing for estimates of effect size as compared with a control condition, and (4) published in English. Three hundred studies met these initial criteria and were obtained for full review, during which three additional inclusion criteria were evaluated: (1) measurement of a discrete alphabet outcomes at posttest, (2) explicit acknowledgment of alphabet training as a component of instruction, (3) sufficient information to calculate an effect size. Discrete measures of alphabet outcomes included tasks of letter name production or recognition, letter sound production or recognition, letter writing, and letter name or sound fluency (i.e., timed) tasks (see Table 1). Short-term studies (defined as encompassing less than one week of instruction), those using pseudoletters, and those assessing only letter discrimination (e.g., finding the match for a particular letter in an array) or reporting composite measures from which specific alphabet outcomes could not be isolated were excluded. Also, for instances in which results from the same sample or a subsample were reported in multiple studies, only one study was included in the meta-analysis. The search yielded 37 studies meeting all criteria.

All studies from two of the National Reading Panel (NRP) meta-analyses (Phonological Awareness and Phonics; NICHD, 2000) and the recent meta-analysis by NELP (2008) were also reviewed for inclusion. These reviews added 20 studies (16 nonduplicate studies found by NRP and 4 found by NELP) to the meta-analysis. Unpublished studies from two additional sources were included. Available online conferences proceedings of relevant professional organizations (i.e., the Society for Research in Child Development, the Society for the Scientific Study of Reading, the American Educational Research Association, and the International Reading Association) were searched for presentations specifically related to the alphabet or knowledge of letters in general. Researchers active in this area were contacted with requests for copies of identified presentations or relevant unpublished work, yielding an additional two studies meeting all selection criteria (Brodeur et al., 2006; M. Brodeur, personal communication, March 10, 2007). Both studies provided yet-unpublished results from well-designed large-scale random control trials in kindergarten classrooms, one of which had undergone peer review as a conference presentation. Florida Center for Reading Research reports (www.fcrr.org/FCRRReports/reportslist.htm) were also searched. This database consists of reviews of popular literacy curricula, including empirical evidence of effectiveness. Each review entails an exhaustive search of published and unpublished studies of the specified curriculum from school districts, independent program evaluators, and publishing companies. All curriculum reviews in the database were assessed, with four meeting selection criteria for inclusion in the meta-analysis.

In sum, the multistep literature search identified 494 studies that were obtained for full review after meeting initial screening criteria. A total of 63 studies met all criteria and are included in the present meta-analysis. These studies yielded a total of 82 independent contrasts between an instructional (treatment) condition and a control, often on multiple outcomes.

Study Coding

Included studies were coded extensively with respect to outcome, instructional features, methodology/design, and participant characteristics. Coding of outcome and instructional foci were required for correct classification of studies prior to analysis; additional details regarding instruction, methodology, and participants were used in moderator analyses. The codes used in the meta-analysis are presented in Table 1. Note that, given our interest in causal relations between alphabet knowledge and phonological awareness, reading, and spelling outcomes, these outcomes (immediate and follow up) were coded only for studies involving pure alphabet instruction. Also, although we initially intended to code and analyze instructional features in much greater detail (e.g., additional instructional foci beyond alphabet or phonological training, instructional materials), insufficient reporting of such features prevented their inclusion. Reliability of the coding scheme was ensured through double coding of 10% of the studies. High inter-rater agreement (average kappa of 0.97) supported the reliability of study coding.

Effect Size Calculation and Analysis

Hedge's *g*, corrected for bias, was used as the measure of effect size. For studies reporting means, standard deviations, and sample size at posttest, the following formulae were used (Ray & Shadish, 1996)

$$g^U = g\left(1 - \frac{3}{4(n_E + n_C - 2) - 1}\right)$$
$$\text{with } g = \frac{(\overline{X}_E - \overline{X}_C)}{S} \text{ and } S = \sqrt{\frac{(n_E - 1)S_E^2 + (n_C - 1)S_C^2}{n_E + n_C - 2}}$$

where g^U is the unbiased estimate of Hedge's *g*, *g* is Hedge's *g* as traditionally defined, n_E is the number of participants in the experimental sample, n_C is the number of participants in the control sample, $\overline{X}_E$ is the mean of posttest scores for participants in the experimental group, $\overline{X}_C$ is the mean of posttest scores for participants in the control group, $S_E{}^2$ is the variance of posttest scores for the participants in the experimental group, and $S_C{}^2$ is the variance of posttest scores for the participants in the control group. For studies failing to provide the numbers required by the above formula, effect sizes were computed using alternative information, such as *F*-tests, *t*-tests, and reported and inferred probability levels (Ray & Shadish, 1996).

Single studies were allowed to contribute multiple effect sizes to the meta-analysis as long as the samples used to compute each effect size were independent of one another. In cases where multiple treatment groups were compared with a single control group, the average effect size was used in analyses. If separate treatment groups were matched with their own controls (e.g., at-risk and non–at-risk treatment groups compared with at-risk and non–at-risk controls, respectively), each comparison was included as a separate effect size. If multiple treatment and control groups existed and specific comparisons were not intended, these were randomly paired and each pair contributed an effect size to the meta-analysis. Finally, for studies with multiple measures within an outcome category (e.g., both a letter name recognition task and a letter name production task), a composite effect size was computed using the formula presented by Rosenthal and Rubin (1986).

Average weighted effect sizes were computed using a random-effects model (Shadish & Haddock, 1994), which accounts for both within- and between-study variance in effect size estimates. Estimation via the random-effects model was chosen for two reasons. Theoretically, the random-effects model was appropriate because we did not assume a single population distribution, given the synthesis of multiple interventions conducted in various settings and using various instructional methods and outcomes. This decision was also supported statistically, as the variability in observed effect sizes often exceeded that attributable solely to sampling error (i.e., the Q homogeneity test statistic was significant; Hedges & Vevea, 1998).

Random-effects analyses were conducted for each of the five alphabet outcomes. Analyses were completed separately for those studies with multiple instructional components and those providing only alphabet instruction, and were further subdivided by the type of instruction provided (in letter names, letter sounds, or both names and sounds, with or without additional phonological training). For studies providing only alphabet instruction, additional analyses were also conducted for immediate and follow-up phonological awareness, reading, and spelling outcomes. For all analyses, a number of statistics, in addition to the average weighted effect size, were computed. These included 95% confidence intervals for the effect,[3] τ^2 or the between-study variability in effect sizes, and the Q statistic to test the homogeneity of effect sizes across studies (Cooper & Hedges, 1994). In addition, a file drawer statistic was calculated (Rosenthal, 1979). This calculation reflects the number of studies with null results required to reduce the average weighted effect size estimate to a nonsignificant value.

Moderator Analyses

Moderator analyses were used to examine factors related to and potential sources of bias in the effect sizes estimated, thus speaking to the validity of findings. Moderator analyses were conducted for overall effect size estimates for the various alphabet outcomes (letter name knowledge, letter sound knowledge, letter writing, and letter name fluency), given sufficient sample size and power. Moderator analyses could not be conducted for letter sound fluency, phonological, reading, or spelling outcomes.

The potential moderating factors investigated include those listed in the last section of Table 1. Similar to the large meta-analyses conducted by the NRP (NICHD, 2000) and NELP (2008), participant and instructional characteristics were examined as potential moderating factors. Participant characteristics included a broad classification of age (early childhood versus elementary school children) and whether participants were considered to be at risk for reading difficulties. Additional instructional characteristics included whether the intervention was classroom- or research lab/clinic-based, whether it was implemented by practicing teachers or research staff, the size of the group to which instruction was administered, and total instructional time. Studies that did not report information for particular moderator variables were dropped from the relevant analyses. Studies dropped because of missing data also included those with multiple treatment groups compared with a single control (i.e., those with dependent effect sizes), when these treatment groups differed on moderator variables.

As recommended by Wortman (1994), an additional set of factors investigated potential bias because of differences in study methodology or quality. Use of random assignment was examined as the study element differentiating experimental and quasi-experimental designs and thus affecting the confidence with which one may make causal attributions regarding the intervention or instruction provided (Shadish, Cook, & Campbell, 2002). Evidence of selection bias or initial nonequivalence among treatment and control groups, considered a major threat to internal validity (Shadish et al., 2002), was examined as a second indicator of study quality. A third methodological factor examined bias related to whether alphabet instruction was provided only to the treatment group (e.g., comparing a supplemental alphabet training program with phonological awareness training or an untreated control) or to both treatment and control groups in various forms (e.g., pitting one method of instruction against another, such as a comprehensive literacy program versus a simpler letter-of-the-week curriculum). Fourth, given the inclusion of both published and unpublished studies,

[3]Confidence intervals for effect size estimates were computed in the following manner (Shadish & Haddock, 1994):

$$\overline{T_{\cdot}^{*}} \pm 1.9\sigma \sqrt{\upsilon_{\cdot}^{*}} \text{ with } \upsilon_{\cdot}^{*}=\frac{1}{\sum_{i=1}^{k}\left(\frac{1}{\upsilon_i+\tau^2}\right)} \text{ and}$$

$$\upsilon_i=\left[\frac{n_E+n_C}{n_E n_C}+\frac{g^{U2}}{2(n_E+n_C-2)}\right]+\tau^2$$

in which $\overline{T_{\cdot}^{*}}$ is the average weighted effect size from the random effects model, $\upsilon_{\cdot}^{*}$ is the variance of the average weighted effect size, v_i is the conditional variance for effect size estimates (g^U) contributed by individual studies (i, ranging from 1 to k), τ^2 is the estimate of the between-studies variance, n_E is the number of participants in the experimental sample, and n_C is the number of participants in the control sample.

studies obtained from peer-reviewed journals were compared with those from other sources as a means of investigating publication bias. Finally, given concerns regarding the "constrained" nature of alphabet knowledge and assessment (Paris, 2005), we examined whether ceiling effects artificially restricted effect size estimates (Cohen, Cohen, West, & Aiken, 2003).

With the exception of instructional time, all moderators were dummy coded for entry into the regression procedure described in Hedges (1994). Instructional time was retained as a continuous variable and analyzed as such. Weighted least-squares regression was used, in which treatment/control contrasts were weighted by the inverse of their unconditional variances (Hedges, 1994). Overall model fit was assessed by comparing the residual variance remaining for each model after other moderators were added. Factors that improved model fit accounted for significant between-study variance in effect size estimates and the extent to which such variability among studies remained after controlling for moderators was assessed via tests of the homogeneity of effect sizes (Q statistic). Standard errors and significance tests for regression coefficients were corrected as specified by Hedges (1994). Factors with significant coefficients were interpreted as reliably predicting the magnitude of effects.

Results

Description of Studies

The studies included in the meta-analysis (N = 63) are listed in Appendixe A and Appendixe B. These studies involved 8,468 participants, 4,466 of whom received treatment involving alphabet instruction. A total of 82 independent effect sizes (k) were calculated, and the number of participants and effect sizes contributing to each meta-analysis is indicated in Table 2 and Table 3. Of the entire sample, most studies (n = 53) included multiple instructional components, typically providing alphabet instruction along with phonological training (n = 44, k = 59). Other instructional targets included oral language (k = 9), writing/printing (k = 11), general print concepts (k = 7), word identification (decoding, k = 12; sight words, k = 12), and book reading/use (k = 11). Instructional components aimed at improving other targets such as speech articulation, listening comprehension, spelling, or handwriting were present to a lesser extent. Ten studies provided pure alphabet instruction: three provided instruction in letter names only (k = 3), four provided instruction in letter sounds only (k = 4), and three provided instruction in both letter names and sounds (k = 5) without any additional instructional components. Total instructional time ranged from 120 to 5,793 minutes (M = 1250.46 minutes, SD = 1335.69).

Additional study characteristics are presented in Appendixe A and Appendixe B, per independent treatment/control contrast[4], with factors included in moderator analyses summarized in Table 4. The studies involved participants in eight countries (Canada, France, Germany, Israel, the Netherlands, New Zealand, the United Kingdom, and the United States). Most instruction involved training in the English alphabet (k = 67), although other alphabetic languages were also represented: Dutch (k = 3), French (k = 6), German (k = 1), and Hebrew (k = 5). Although most studies were conducted in school settings with preschool- or kindergarten-aged children (k = 68), a few studies involved only elementary school students (k = 10) or a combination of kindergarten and elementary school students (k = 4; see Table 4). Many participants were considered at risk for reading difficulties because

[4]*k* technically refers to independent treatment/control contrasts and not necessarily individual studies. Most meta-analyses, however, report results in terms of "studies," typically extracting only a single effect size from each study or viewing each independent treatment/control contrast as a separate study in its own right. For this reason, together with concerns regarding the ease of reading, the terms *independent treatment/control contrast* and *study* will be used interchangeably.

of socioeconomic, disability, or low skill-level status, and this was particularly true for elementary school-aged participants.

Impact of Multicomponential Instruction on Alphabet Outcomes

Table 2 presents effect size results for multicomponent studies or those studies providing instruction in literacy domains other than simply alphabet knowledge. As statistical power was often limited, particularly given the small sample sizes once studies were disaggregated by instructional foci, 95% confidence intervals are helpful in evaluating the precision of the estimates of effect sizes. A confidence interval that does not contain zero indicates that the effect size was significantly different from 0.

Instruction had a significant impact on every alphabet outcome except letter name fluency. Overall effect sizes ranged from $g^U = 0.65$ for letter sound knowledge to $g^U = 0.43$ for letter name knowledge. In all cases except letter sound fluency, these overall effect sizes were heterogeneous (significant Q statistic), with between-study variance estimates (τ^2) ranging from 7% for letter writing to 32% for letter sound knowledge. As seen in Table 2, these variance estimates often changed considerably when studies were classified according to instructional components; nonsignificant homogeneity statistics ought to be interpreted with caution, however, given the small sample sizes in many of these categories.

Disambiguating by instructional components allowed for a more nuanced examination of the overall effects. Letter name outcomes were reliably affected by when letter name or both letter name and sound instruction were combined with phonological training. With the exception of a single study (van Bysterveldt, Gillon, & Moran, 2006), all instruction targeting letter sound knowledge reliably improved letter sound outcomes, whether such instruction did or did not include phonological training. Moreover, letter name instruction also led to significant impacts on letter sound knowledge although these effects were somewhat smaller than those for letter sound instruction. Letter sound fluency was reliably affected by letter sound plus phonological instruction. Notably, the van Bysterveldt et al. (2006) study producing the negative effect on letter sound outcomes also produced a negative effect on letter name outcomes; the negative effect, however, may be attributable to that particular study rather than a general failure of combined letter name and sound instruction to improve alphabet outcomes.

Impact of Pure Alphabet Instruction on Alphabet and Early Literacy Outcomes

Table 3 presents effect size results for studies providing only alphabet instruction. Despite generally positive effects of pure alphabet instruction on alphabet outcomes, most effect sizes were not reliable. The sole exception was letter sound knowledge, which showed a significant overall effect. Letter sound knowledge also showed a significant impact on letter name instruction, but this finding was based on only a single effect size (McMahon, Rose, & Parks, 2003). Unlike results for multicomponent studies, between-study variability was minimal (maximum of 12%) and homogeneity of effect sizes could not be rejected. Caution is warranted in interpreting these results, however, given the small sizes involved.

Short- and long-term effects of alphabet instruction on phonological, reading, and spelling skills are also reported in Table 3. Phonological outcomes did not show an overall impact of alphabet instruction when measured immediately following intervention; a significant positive impact of letter name instruction found in a single study (McMahon et al., 2003) was accompanied by a significant negative effect of combined letter name and sound instruction. Conversely, immediate reading outcomes showed a significant overall impact of alphabet instruction but nonsignificant impacts when considering the specific type of instruction provided. The sole study assessing spelling at immediate posttest (Stuart, 1999) also failed to show a reliable effect of letter sound instruction on this outcome. Effect sizes were heterogeneous for phonological outcomes, with 44% of the variance between-studies. Reading outcomes, on the other hand, showed essentially no between-study variability.

Only four studies included follow-up assessments (Fugate, 1997, 2 month follow-up; Johnston & Watson, 2004, 9 month follow-up; Schneider, Roth, & Ennemoser, 2000, 3 month follow-up for phonological awareness, 1 year follow-up for reading and spelling; Stuart, 1999, 1 year follow-up). None of the follow-up effect sizes significantly differed from zero. Similar to the result presented above, effect sizes were heterogeneous for phonological and spelling outcomes, with between-study variability ranging from 40% to 46%. Reading outcomes again showed almost no between-study variability.

Moderator Analyses

Results of moderator analyses are presented in Table 5, with estimated effects and contrasts among levels of moderating factors presented in Table 4. For letter name and letter sound knowledge outcomes, studies conducted in school settings showed greater impacts than those conducted at home. Studies of letter name knowledge also demonstrated differences in effect sizes according to the size of the group to which instruction was provided, with small groups having larger impacts than individual tutoring. Finally, studies of letter name knowledge were reliably influenced by the amount of time devoted to instruction; studies providing more instructional time tended to have larger impacts.

Study quality differences were only predictive of variability in effect sizes across studies in a single case: True experiments showed reliably larger effects than quasi-experiments on letter name fluency outcomes. Notably, publication bias did not reliably affect results despite trends favoring peer-reviewed publications. Also, note that for all outcomes except letter name knowledge, accounting for potential moderators reduced the between-study variability to nonsignificant levels. The test of homogeneity of effect sizes continued to be rejected for analyses involving letter name outcomes.

Discussion

In its synthesis of more than 60 studies from the early reading literature, the present study demonstrates a significant impact of instruction on children's alphabet learning. Effect size magnitude depended not only on the type of alphabet knowledge assessed, but also instructional factors such as skills taught, setting, grouping, and duration.

Impact on Alphabet Knowledge

Letter name knowledge, letter sound knowledge, and letter writing outcomes showed effects ranging from 0.14 to 0.65 across the various domains of alphabet knowledge when considering both multicomponential and pure alphabet instruction. According to Cohen's guidelines, these represent small-to-moderate effects (Cohen, 1988); however, when compared with contemporary efforts to improve outcomes via educational programs, these effects may be considered of greater magnitude (Hill, Bloom, Black, & Lipsey, 2007; Konstantopoulos & Hedges, 2008). Effects tended to be larger (moderate effect sizes) and more aligned with the NELP findings when multicomponential instruction was provided, perhaps lending support to notions of reciprocal relations among emergent literacy skills (Burgess & Lonigan, 1998; Lonigan et al., 2000; McBride-Chang, 1999; NICHD, 2000; Wagner et al., 1994). Moreover, effects of multicomponential instruction tended to be slightly larger than those reported in the NELP study, likely because of the provision of alphabet instruction in all synthesized studies.

Effects for fluency outcomes were less clear. For multicomponential studies, letter naming fluency was the only outcome to show no effect of instruction, yet a moderate (though also nonsignificant) effect was found when letter names constituted the sole focus of instruction. Conversely, multicomponential studies showed a reliable moderate effect on letter sound fluency outcomes that was not apparent when considering the study providing only letter sound training. The positive effect for multicomponential studies on letter sound fluency may be partially explained by the close match between instructional target and assessed skill: All studies assessing sound fluency provided explicit instruction in letter–sound correspondences. In general, however, these findings were not wholly unexpected, as fluency is often touted as one of the most difficult aspects of literacy to improve (see e.g., Kuhn & Stahl, 2003; Torgesen & Hudson, 2006) even when restricted to the rapid naming of letters or sounds (de Jong & Vrielink, 2004).

Altogether, the previously presented results suggest that specific domains of alphabet knowledge can be enhanced through instruction to varying degrees. Importantly, effect size magnitude did not appear to be biased by ceiling effects, publication bias, or study quality (with the single exception of letter name fluency for the latter). Given these findings, we are confident that the overall impact results are an accurate portrayal of the selected studies' effects on alphabet learning. On the whole, these modest effect sizes for alphabet knowledge are somewhat surprising, given (a) the emphasis placed on alphabet learning by research (Adams, 1990; Whitehurst & Lonigan, 1998), educational (NAEYC, 1998), and policymaking (U.S. Department of Education, 2002, 2003) communities, (b) the close alignment between alphabet instruction and alphabet assessments used to assess its efficacy, and (c) the meta-analytic results for other literacy skills (Bus & van IJzendoorn, 1999; NELP, 2008; NICHD, 2000; Wagner, 1988). The NRP, for example, reported effects ranging from 0.53 to 0.86 for phonological awareness and phonics training on primary students' phonological, reading, and spelling outcomes (NICHD, 2000). These estimates were even greater for at-risk students (0.58 to 0.95), a result not seen in the present analysis, and ranged up to 2.37 for particular subgroups of children.

The modest effects may have a number of explanations. First, alphabet learning may be of a different nature than other skills like phonological awareness, requiring significant amounts of rote memorization and repeated practice. Second, many studies were not particularly focused on providing letter name or sound instruction, and such instruction was often included as only a small or incidental portion of a larger literacy program (e.g., teaching letters to serve as "placeholders" for facilitating phonological awareness development). Third, many children have opportunities to learn about letters outside of a structured intervention or research study. In the United States, the country in which the majority of studies were conducted, parents and teachers alike tend to impart letter knowledge to young children, particularly focusing on letter names (Ellefson, Treiman, & Kessler, 2009). Children in control conditions may thus learn letter names to a similar extent as children receiving additional instruction. This explanation is supported by the smaller effects on letter name learning. Conversely, a lack of emphasis on letter sounds may explain the more substantial, yet still modest, effects noted for this outcome.

Alternatively, the small-to-moderate effect size estimates may be an authentic representation of our current ability to foster alphabet knowledge development during early literacy instruction. The question then turns to whether such gains are adequate. Although many children may easily acquire alphabet knowledge from incidental or informal teaching during home and school literacy activities (e.g., Aram, 2006; Thompson, Fletcher-Flinn, & Cottrell, 1999), other children, particularly those from disadvantaged backgrounds or those at risk for later reading difficulties, may not (National Research Council, 1998). These children often arrive in kindergarten at substantial disadvantages in their alphabet and early literacy development (Lonigan, 2003; Zill & Resnick, 2006), with this gap widening as formal reading instruction begins (Stanovich, 1986; Torgesen, 2002). “Catching up” these children to meet grade-level standards is often difficult. For instance, the present synthesis does not support the use of current instructional practices to close this gap in alphabet knowledge; effect sizes were no larger for children at risk for reading difficulties than those who were not. Similar to findings regarding instruction in other early literacy skills such as decoding (Foorman, Fletcher, & Francis, 2002), more intensive, explicit alphabet instruction may be necessary to lessen the achievement gap. These facts may call for greater attention to the effectiveness of alphabet instruction during the early years.

Foci and Delivery of Instruction

One of the benefits of the present meta-analysis was the ability to disambiguate effects based on the foci of instruction. In examining effects according to the alphabet and phonological components taught, larger effects were often noted when (a) the alphabet components taught matched the outcome, and (b) alphabet and phonological awareness instruction was combined. Interpretation of these analyses, however, is tempered by the small number of available studies. Once the larger pools of studies were subdivided according to the type(s) of instruction provided, sample sizes were often too small to warrant great confidence in the effect sizes generated. For example, van Bysterveldt et al. (2006) was the sole multicomponential study to provide letter name and sound instruction without phonological training, in the form of a shared parent–child storybook reading program. In such cases, generated effect sizes may be due to idiosyncratic features of particular studies and are susceptible to any biases present in the original studies. In the van Bysterveldt et al. study, the negative effects on letter name and letter sound knowledge may have been attributable to a number of factors: the implicit instructional method, implementation by parents, initial selection biases favoring the control group, and so forth. Noting the small number of studies that use particular instructional foci is important, however, to identify gaps in the literature. We hope that our findings serve as impetus for future research and replication.

One interesting finding deserving of further examination and replication concerns the impact of letter name instruction on letter sound learning. Studies providing letter name instruction as the only alphabet component showed reliable, positive impacts on children’s letter sound learning. This result lends causal support to the argument for letter name-to-sound facilitation, discussed within the context of letter names that provide cues for learning letter sounds (Evans et al., 2006; McBride-Chang, 1999; Share, 2004; Treiman, Tincoff, & Richmond-Welty, 1996; Treiman et al., 1998). Further validation of the effect is warranted, as is investigation of the effect’s mechanism, whether because of letter names cues or other factors such as differences in letter frequency or familiarity.

The results of moderator analyses yielded minimal information regarding how alphabet instruction might most efficiently and effectively proceed. Instruction of greater duration and that is provided in a small-group context were more effective in promoting letter name knowledge. The benefit of small-group instruction has been repeatedly recognized within the early literacy literature as a hallmark of effective literacy instruction (Wharton-McDonald et al., 1997; Wharton-McDonald, Pressley, & Hampston, 1998) and linked to enhanced skill development in students (Connor, Morrison, & Slominski, 2006; NICHD, 2000). Instruction provided at home by parents was consistently the least effective means of promoting alphabet instruction. Although only a limited number of such studies were included in the present analysis, parent and home-based interventions were found similarly ineffective for various literacy outcomes in the NELP review (NELP, 2008). This reduced impact may be due to the inherent difficulties in implementing home-based programs. Home-based treatments may be more difficult to organize and over-see, with fidelity to the treatment program suffering (van Otterloo, van Der Leij, & Veldkamp, 2006). The content of such programs may also be less focused on teaching specific components of literacy as opposed to more global abilities (e.g., oral language, print awareness, general cognitive skills) or require better parent training to be implemented in a manner that affects children's learning.

On the other hand, teachers and classroom instruction proved just as effective as the more controlled instruction provided by researchers in clinics and laboratories. This finding is important, demonstrating that literacy practices benefiting children's alphabet development may be implemented in ecologically valid settings. More research detailing the training and support necessary to secure these effects by teachers is warranted, as such details were often not noted in the research reports analyzed for this study. In general, future studies would benefit from more detailed reporting of key instructional and implementation features to facilitate identification of additional moderators of instructional effects.

Impact of Alphabet Instruction Beyond Alphabet Knowledge Outcomes

Results were generally inconclusive with respect to the causal relations between alphabet learning and development of other early literacy skills. Small effects on reading skills were found when assessed immediately following instruction, but effects were no longer apparent 2 to 12 months later. No effects were found for phonological awareness or spelling outcomes at either immediate or follow-up assessment, nor did initial effects on alphabet outcomes persist. Notably, the subsample of studies included in these analyses was small, and none were explicitly designed as longitudinal investigations concerning alphabet knowledge acquisition and the development of other literacy skills. The comparison conditions involved in the studies are also important to consider. Of the seven studies included in the phonological awareness analyses, for example, two provided phonological training to the comparison group and two provided alternative forms of alphabet instruction hypothesized to be less effective than the treatment under study. Thus, more than half of the studies provided literacy training to the control condition, which might have influenced phonological awareness and attenuated effect size estimates. It is also possible that pure letter name or sound instruction does not readily transfer to reading and spelling without instruction and practice in using alphabet knowledge for these purposes (e.g., blending; Feitelson, 1988).

Noting the inconsistencies in the effect size estimates for long-term reading and spelling outcomes, we revisited these four studies in the hope of distilling shared components trending toward positive or negative effects. Unfortunately, further examination did not elucidate any factors linked to follow-up outcomes. Methodologically, positive and negative effects were found when using quasi-experimental designs, in the presence of selection biases, with teacher- and researcher-implemented instruction, and for samples including older and younger, at-risk and non–at-risk children. The content and delivery of instruction across studies was also diverse. Fugate (1997) found positive outcomes for an experimental daily tutoring program that trained grade 1 students to mastery-level letter naming abilities over the course of 12 days as compared with students who used that time for journal writing. Stuart (1999) also found positive long-term outcomes when working with kindergarten students over a 12 week period, comparing a commercially available program to teach letter sounds to shared storybook reading. In comparison, the Johnston and Watson (2004) study, which showed null or negative effects, provided either explicit letter sound instruction or training in matching pictures to sight words during 20 lessons across 10 weeks. The Schneider et al. (2000) study, also resulting in negative effects, provided children with either letter sound or phonological awareness instruction. Given that children were initially screened into the study based on phonological difficulties, the larger gains for children receiving the latter type of training are unsurprising.

These inconclusive results should not be misconstrued as disproving causal relations between alphabet knowledge and literacy skill development, nor ought they be interpreted as suggesting the futility of providing early alphabet instruction. Rather, these findings ought to stimulate research expressly designed to answer important questions concerning the role of alphabet knowledge development and later literacy abilities.

Limitations and Future Directions

Because meta-analytic data are essentially the existing studies in a given area, the present study was limited by the quality and design of research studies conducted in this domain. Within- and between-study confounds may jeopardize the validity of findings. For example, studies allowing teachers to voluntarily implement a new alphabet instruction technique may capitalize on this selection bias to produce larger effects. Similarly, between-study comparisons may not be entirely appropriate when studies differ largely in content or methodology, particularly when sample sizes are small. Although we attempted to examine such threats to validity via moderator analyses, such threats remain real limitations of any meta-analytic work.

Relatedly, we must point out that the results of moderator analyses may also be influenced by between- and within-study confounds. The factors included in moderator analyses were not directly manipulated and thus may have been confounded with one another within studies (e.g., many studies providing explicit letter sound instruction also provided phonological awareness training). Moderators may also have been confounded with methodological variables. Empirical validation, in which moderating variables are explicitly manipulated, is required for these effects to be causally interpretable.

Furthermore, additional research on *how* to effectively impart alphabet knowledge remains necessary. Despite our efforts to capture meaningful variations in instructional content and implementation for moderator analyses, details regarding individual studies could be coded only if they were explicitly mentioned within the text of research reports. Many proposed research questions concerning additional potential moderators of the effect of instruction on alphabet learning (e.g., organization of alphabet lessons including the order in which letters were taught, instructional materials, fidelity of implementation, training of instructors) could not be answered because of lack of information. Future design work, in which various ways of promoting mastery of letters and sounds are contrasted, is necessary to reliably answer such detailed questions concerning the efficacy and efficiency of alphabet instruction. Finally, as previously discussed, research aimed at elucidating the causal role of alphabet knowledge in promoting literacy development is required.

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(* indicates inclusion in meta-analysis)

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Table 1

Descriptions of Study Codes Indicating Outcome and Moderator Variables

Study code	Description
Outcome(s)	
Letter name knowledge	Assessments involving untimed recognition or production of letter names such as asking children to name individual letters depicted on flashcards
Letter sound knowledge	Assessments involving untimed recognition or production of letter sounds such as asking children to give the associated sound for individual letters depicted on flashcards
Letter writing	Assessments involving writing letters in response to oral prompts or timed writing of the alphabet such as asking children to write the alphabet from beginning to end
Letter name fluency	Assessments involving quickly naming letters such as RAN-letters and DIBELS Letter Naming Fluency
Letter sound fluency	Assessments involving quickly producing the sounds of letters such as in adaptations of RAN-letters and DIBELS fluency tasks, in which the sounds of letters are rapidly produced instead of the names
Phonological awareness	Assessments requiring awareness or manipulation of speech sounds including rhyming, sound categorization or matching, and sound blending or deletion
Reading	Assessments of reading including decoding, sight word recognition, and oral reading fluency
Spelling	Assessments of spelling including traditional dictation tasks and invented spelling
Study quality	
Experiment vs. quasi-experiment	Experiments used random assignment to assign participants to conditions, whether as individuals or clusters; quasi-experiments assigned participants to conditions using methods other than random assignment
Evidence of selection biases	Pretest or other initial differences between the participants assigned to treatment versus control which may bias interpreting posttest differences between the groups
Other methodological factors	
Alphabet instruction isolated to treatment group	Letter name or sound instruction was provided only to the participants in the treatment condition
Evidence of potential ceiling effects	Mean(s) on alphabet posttest measure(s) were within 1 *SD* of the maximum possible score
Publication bias	Study was published in a peer-reviewed journal as opposed to other, unpublished sources
Participant characteristics	
Age	General age of children included in the sample classified as early childhood (preschool, kindergarten) or elementary school (grades 1–3)
At-risk for reading difficulties	Majority of children in the sample considered at risk for later reading difficulties because of minority or low socioeconomic status, identification as learning disabled or language impaired, or poor emergent literacy skills
Instructional characteristics	
Setting	Setting/context in which treatment was delivered was school based (preschool classrooms, elementary school classrooms, school pullout/small-group program), home based, or research based (laboratory, clinic,)
Implementer	Person who provided instruction (teacher employed by an educational agency versus researcher or research staff)
Group size	Grouping unit (i.e., number of students) in which instruction was delivered (individual tutoring, small groups, whole class)
Time	Number of minutes of instruction received by participants

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Table 2

Average Weighted Effect Sizes and Relevant Statistics for Multicomponential Studies

Type of instruction	*k*	*n*	Average weighted effect size	95% CI		τ^2	Homogeneity of effect sizes		File drawer statistic
				Lower bound	Upper bound		*Q*	*p*	
Letter name knowledge outcomes									
Full sample	27	2631	0.43	0.22	0.64	0.24	159.21	< .001	549
Studies providing LN instruction									
With PA	1	33	1.00	0.27	1.72				1
Without PA	2	72	0.20	−0.24	0.65	−0.02	0.86	.353	
Studies providing LS instruction									
With PA	6	461	0.18	−0.01	0.36	0.00	4.24	.515	
Studies providing both LN and LS instruction									
With PA	17	2041	0.58	0.31	0.86	0.27	125.19	< .001	451
Without PA	1	24	−1.85	−2.82	−0.88				3
Letter sound knowledge outcomes									
Full sample	36	3616	0.65	0.44	0.86	0.32	270.92	< .001	2176
Studies providing LN instruction									
Without PA	3	48	0.82	0.22	1.41	0.00	0.76	.684	3
Studies providing LS instruction									
With PA	17	1863	0.85	0.63	1.08	0.15	69.36	< .001	1048
Studies providing both LN and LS instruction									
With PA	15	1681	0.48	0.17	0.79	0.29	106.55	< .001	167
Without PA	1	24	−1.31	−2.20	−0.42				1
Letter writing outcomes									
Full sample	6	741	0.59	0.31	0.86	0.07	14.70	.012	76
Studies providing LS instruction									
With PA	4	601	0.60	0.25	0.94	0.09	11.30	.010	41
Studies providing both LN and LS instruction									
With PA	2	140	0.58	−0.05	1.21	0.15	3.40	.065	
Letter name fluency outcomes									
Full sample	17	2016	−0.02	−0.25	0.21	0.17	82.89	< .001	
Studies providing LN instruction									

Type of instruction	k	n	Average weighted effect size	95% CI Lower bound	95% CI Upper bound	τ^2	Homogeneity of effect sizes Q	Homogeneity of effect sizes p	File drawer statistic
With PA	1	43	−0.61	−1.23	0.00				
Without PA	1	139	0.16	−0.20	0.51				
Studies providing LS instruction									
With PA	7	1385	0.07	−0.09	0.23	0.02	10.23	.115	
Without PA	1	24	−0.32	−1.13	0.48				
Studies providing both LN and LS instruction									
With PA	7	425	−0.04	−0.76	0.69	0.84	65.05	< .001	
Letter sound fluency outcomes									
Full sample	4	428	0.58	0.38	0.79	0.00	1.21	.752	24
Studies providing LS instruction									
With PA	3	404	0.60	0.48	0.72	−0.02	0.65	.723	22
Without PA	1	24	0.29	−0.52	1.09				

Note, *k* = number of independent contrasts/studies; *n* = total number of children; CI = confidence interval; τ^2 = between-study variability; LN = letter name; PA = phonological awareness; LS = letter sound.

Table 3

Average Weighted Effect Sizes and Relevant Statistics for Studies Providing Only Alphabet Instruction

Type of instruction	*k*	*n*	Average weighted effect size	95% CI Lower bound	95% CI Upper bound	τ^2	Homogeneity of effect sizes *Q*	Homogeneity of effect sizes *p*	File drawer statistic
Letter name knowledge outcomes									
Full sample	8	389	0.14	−0.10	0.37	0.02	8.16	.319	
Studies providing LN instruction	1	28	0.00	−0.86	0.86				
Studies providing LS instruction	2	172	0.08	−0.22	0.39	0.00	0.12	.731	
Studies providing LN and LS instruction	5	189	0.23	−0.20	0.67	0.12	7.75	.101	
Letter sound knowledge outcomes									
Full sample	4	856	0.48	0.40	0.55	0.00	2.57	.462	20
Studies providing LN instruction	1	628	0.50	0.34	0.66				9
Studies providing LS instruction	2	204	0.24	−0.04	0.53	0.00	0.19	.661	
Studies providing LN and LS instruction	1	24	0.41	−0.40	1.22				
Letter writing outcomes									
Full sample									
Studies providing LS instruction	1	112	0.31	−0.06	0.68				
Letter name fluency outcomes									
Full sample									
Studies providing LN instruction	1	39	0.64	0.00	1.28				
Letter sound fluency outcomes									
Full sample									
Studies providing LS instruction	1	34	−0.33	−1.01	0.35				
Immediate phonological awareness outcomes									
Full sample	6	829	−0.17	−0.73	0.40	0.44	59.56	< .001	
Studies providing LN instruction	1	516	0.62	0.44	0.79				11
Studies providing LS instruction	4	284	−0.22	−0.76	0.33	0.26	17.24	.001	
Studies providing LN and LS instruction	1	29	−0.98	−1.75	−0.20				1
Immediate reading outcomes									
Full sample	6	397	0.21	0.02	0.40	−0.01	4.60	.467	1
Studies providing LN instruction	1	39	0.49	−0.14	1.13				
Studies providing LS instruction	5	358	0.18	−0.03	0.39	0.00	3.74	.442	

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Type of instruction	k	n	Average weighted effect size	95% CI Lower bound	95% CI Upper bound	τ^2	Homogeneity of effect sizes Q	Homogeneity of effect sizes p	File drawer statistic
Immediate spelling outcomes									
Full sample									
Studies providing LS instruction	1	112	0.30	−0.08	0.67				
Follow-up phonological awareness outcomes									
Full sample									
Studies providing LS instruction	3	264	0.01	−0.80	0.82	0.46	20.57	< .001	
Follow-up reading outcomes									
Full sample	4	285	0.11	−0.12	0.35	0.00	2.11	.550	
Studies providing LN instruction	1	39	0.25	−0.38	0.88				
Studies providing LS instruction	3	246	0.09	−0.15	0.34	0.00	1.91	.384	
Follow-up spelling outcomes									
Full sample									
Studies providing LS instruction	3	264	0.14	−0.62	0.89	0.40	18.20	< .001	

Note, k = number of independent contrasts/studies; n = total number of children; CI = confidence interval; τ^2 = between-study variability; LN = letter name; LS = letter sound.

Table 4

Effect Sizes as a Function of Moderator Variables

	Outcome							
	Letter name knowledge		Letter sound knowledge		Letter writing		Letter name fluency	
Moderator	**k**	**Effect size**	**k**	**Effect size**	**k**	**Effect size**	**k**	**Effect size**
Use of random assignment								
Yes	25	0.40	26	0.65	1	0.915	12	0.18 *
No	13	0.31	16	0.56	6	0.497	6	−0.37
Presence of selection bias(es)								
Yes	24	0.33	22	0.51	5	0.497	12	−0.09
No	14	0.43	20	0.74	2	0.746	6	0.21
Alphabet instruction isolated to the treatment group								
Yes	35	0.38	37	0.61	7	0.545	16	0.04
No	3	0.20	5	0.63	0		2	−0.24
Potential ceiling effects								
Yes	11	0.47	9	0.53	3	0.705		
No	19	0.35	25	0.68	4	0.427		
Publication bias								
Peer-reviewed journal	24	0.46	35	0.68	3	0.336	8	−0.08
Other source	14	0.22	6	0.45	4	0.662	10	0.07
Participant age								
Early childhood (preschool/kindergarten)	33	0.37	35	0.65	5	0.601	14	0.09
Elementary	5	0.34	6	0.43	2	0.381	3	0.32
Participants at risk for reading difficulties								
Yes	26	0.40	18	0.42	2	0.569	7	−0.14
No	2	0.58	4	0.57	0		2	0.28
Instructional setting								
School	34	0.41 #	35	0.63 #	6	0.549	15	0.11
Home	2	−0.80 #	2	−0.61 #	0		2	0.24

	Outcome							
	Letter name knowledge		Letter sound knowledge		Letter writing		Letter name fluency	
Moderator	**k**	**Effect size**	**k**	**Effect size**	**k**	**Effect size**	**k**	**Effect size**
Lab or clinic	1	0.00	1	0.78	0		0	
Implementer								
Teacher	18	0.54	16	0.63	5	0.594	9	0.16
Research staff	16	0.31	23	0.71	1	0.5	5	0.01
Group size								
Individual	4	−0.26 #	9	0.39	2	0.355	4	0.30
Small group	21	0.52 #	20	0.73	2	0.569	7	0.07
Whole class	12	0.24	11	0.48	3	0.607	5	0.06
Instructional time[a]								
Minimum	30	−0.26 *	32	0.57	3	0.508	15	0.11
Mean		0.31		0.50		0.546		0.15
Max		0.98		0.42		0.565		0.19

Note. Contrasts represent results of pairwise comparisons within factors.

[a]Total minutes of instructional time was highly positively skewed, and a logarithmic transformation of this variable was used in all analyses (Tabachnick & Fidell, 1996). Because this moderator was a continuous variable, effects are listed for instructional time at the minimum, mean, and maximum.

*Contrast between effect sizes is significant at $p < .05$.

#Contrast between effect sizes trended towards significance at $p < .10$ and significantly improved model fit at $p < .05$.

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Table 5

Fit and Homogeneity Statistics for Moderator Analyses

		Model Fit				Test of Homogeneity of Effect Sizes		
Moderator	***k***	**ΔR^2**	**ΔQ**	***df***	***p***	***Q***	***df***	***p***
Letter name knowledge outcomes								
Use of random assignment	38	0.01	0.35	1	.554	66.98	35	.001
Presence of selection bias(es)	38	0.01	0.34	1	.560	66.99	36	.001
Alphabet instruction isolated to the treatment group	38	0.01	0.32	1	.569	67.00	36	.001
Potential ceiling effects	30	0.01	0.49	1	.485	61.57	28	< .001
Publication bias	38	0.03	2.30	1	.129	65.03	36	.002
Participant age	38	0.00	0.01	1	.909	67.31	36	.001
Participants at risk for reading difficulties	28	0.01	0.33	1	.568	58.38	26	< .001
Instructional setting	37	0.13	8.66	2	.013	57.23	34	.008
Implementer	34	0.04	2.12	1	.145	50.49	32	.020
Group size	37	0.14	9.01	2	.011	55.48	34	.011
Instructional time	30	0.19	10.72	1	.001	46.40	28	.016
Letter sound knowledge outcomes								
Use of random assignment	42	0.00	0.24	1	.627	52.82	40	.084
Presence of selection bias(es)	42	0.03	1.55	1	.213	51.50	40	.105
Alphabet instruction isolated to the treatment group	42	0.00	0.00	1	.950	53.05	40	.081
Potential ceiling effects	34	0.01	0.44	1	.506	43.46	32	.085
Publication bias	41	0.03	1.35	1	.245	51.70	40	.102
Participant age	41	0.01	0.72	1	.395	52.27	39	.076
Participants at risk for reading difficulties	22	0.02	0.25	1	.614	15.19	20	.765
Instructional setting	38	0.15	7.16	2	.028	40.76	35	.232
Implementer	39	0.00	0.19	1	.665	42.80	37	.236
Group size	40	0.05	2.43	2	.296	45.73	37	.154
Instructional time	32	0.01	0.15	1	.703	30.06	30	.463
Letter writing outcomes								

		Model Fit				Test of Homogeneity of Effect Sizes		
Moderator	***k***	**Δ*R*²**	**Δ*Q***	***df***	***p***	***Q***	***df***	***p***
Use of random assignment	7	0.20	1.18	1	.278	4.83	5	.437
Presence of selection bias(es)	7	0.11	0.64	1	.423	5.37	5	.373
Potential ceiling effects	7	0.21	1.26	1	.262	4.75	5	.447
Publication bias	7	0.27	1.63	1	.202	4.38	5	.497
Participant age	7	0.10	0.62	1	.432	5.40	5	.369
Implementer	6	0.01	0.04	1	.836	5.21	4	.267
Group size	7	0.11	0.64	2	.725	5.26	4	.261
Instructional time	3	0.01	0.01	1	.910	1.60	1	.206
Letter name fluency outcomes								
Use of random assignment	18	0.18	4.65	1	.031	20.69	16	.191
Presence of selection bias(es)	18	0.06	1.45	1	.229	23.90	16	.092
Alphabet instruction isolated to the treatment group	18	0.02	0.58	1	.447	24.77	16	.074
Publication bias	18	0.02	0.37	1	.542	24.98	16	.070
Participant age	17	0.06	0.54	1	.463	8.41	15	.906
Participants at risk for reading difficulties	9	0.05	1.04	1	.309	20.24	7	.005
Instructional setting	17	0.01	0.12	1	.726	8.83	15	.886
Implementer	14	0.03	0.27	1	.603	8.44	12	.750
Group size	16	0.08	0.72	2	.698	8.22	13	.829
Instructional time	15	0.00	0.03	1	.860	8.27	13	.825

k = number of independent contrasts/studies

Appendix A

Effect Sizes and Study Characteristics of Independent Treatment/Control Contrasts Included in Meta-Analyses

Study	Source	Study type	Design	Country	Language	Age	At-risk sample	Setting	Implementer	Group size	LN	LS	PA	Time (min)	Isolated alpha
Angerilli (1999)	PQ	T/D	Exp	Canada	English	K		EC	RA	SG	N	Y	Y		Y
Aram & Biron (2004)	P/E	J	QED	Israel	Hebrew	Pre	A	PO	RA	SG	Y	Y	Y	1650	Y
Aram (2006)	P/E	J	QED	Israel	Hebrew	Pre	A	PC	T	SG	Y	Y	Y	1250	Y
	P/E	J	Exp	Israel	Hebrew	Pre	A	PC	T	SG	Y	Y	Y	1250	Y
Ball & Blachman (1988)	FCRR	J	Exp	USA	English	K		PO	RA	SG	Y	Y		560	Y
Ball & Blachman (1991)	P/E	J	Exp	USA	English	K		PO	RA	SG	Y	Y		560	Y
Bara, Gentaz, Colé, & Sprenger-Charolles (2004)	P/E	J	QED	France	French	K		PO	RA	SG	N	Y	N	175	N
Beech, Pedley, & Barlow (1994)	P/E	J	QED	UK	English	GE			RA	I	N	Y	Y	135	Y
Blachman, Ball, Black, & Tangel (1994)	NELP	J	QED	USA	English	K	A	EC	T	SG	Y	Y	Y	770	Y
Boyle (2006)	PQ	T/D	Exp	USA	English	Pre	A	H	Pt	I	Y	Y	Y		Y
Brodeur et al. (2006)	C/R	P	Exp	Canada	French	K	A	EC	T	WC	Y	Y	Y	750	Y
	C/R	P	Exp	Canada	French	K	N	EC	T	WC	Y	Y	Y	750	Y
Brodeur (2007)	C/R	U	Exp	Canada	French	K	A	EC	T	WC	Y	Y	Y	1260	Y
	C/R	U	Exp	Canada	French	K		EC	T	WC	Y	Y	Y	1260	Y
	C/R	U	Exp	Canada	French	K		EC	T	WC	Y	Y	Y	1260	Y
Caplovitz (2005)	PQ	T/D	Exp	USA	English	Pre		H	Pt	I	Y	N	N	337	Y
Castle, Raich, & Nicholson (1994)	NELP	J	Exp	New Zealand	English	K	A	PO	RA	SG	N	Y	Y	400	Y
	NELP	J	Exp	New Zealand	English	K	A	PO	RA	SG				300	Y
Culatta, Kovarsky, Theadore, Franklin, & Timler (2003)	P/E	J	QED	USA	English	Pre	A	PC	RA	WC	Y	Y	N		Y
de Jong, Seveke, & van Veen (2000)	P/E	J	Exp	Netherlands	Dutch	K		EC	T	SG	N	Y	Y	1500	Y
de Jong & Vrielink (2004)	P/E	J	Exp	Netherlands	Dutch	G1		EC	T	SG	N	Y	N	1250	Y
Edwards (2000)	PQ	T/D	Exp	USA	English	K	A	EC	T	SG	Y	Y	Y	3390	Y
	P/E	J	Exp	USA	English	Pre/K		RL	RA	I	N	Y	N		N
Ehri & Wilce (1987)	NRP	J	Exp	USA	English	K			RA	I	N	Y	Y	160	N
Eidlitz-Neufeld (2002)	P/E	T/D	QED	Canada	English	K		EC	T	WC	N	Y	Y		Y
	P/E	T/D	QED	Canada	English	K		EC	T	WC	N	Y	Y		Y
	P/E	T/D	QED	Canada	English	G1		EC	T	WC	N	Y	Y		Y
Farrell (1978)	P/E	T/D	Exp	USA	English	GE	A	PO	RA	WC	Y	Y	N	360	Y
	P/E	T/D	Exp	USA	English	GE	A	PO	RA	WC	Y	Y	N	360	Y

Study	Source	Study type	Design	Country	Language	Age	At-risk sample	Setting	Implementer	Group size	LN	LS	PA	Time (min)	Isolated alpha
	P/E	T/D	Exp	USA	English	GE	A	PO	RA	WC	Y	Y	N	360	Y
Fuchs et al. (2001)	NELP	J	Exp	USA	English	K	S	EC	T		N	Y	Y		Y
	NELP	J	Exp	USA	English	K	N	EC	T		N	Y	Y		Y
	NELP	J	Exp	USA	English	K	N	EC	T		N	Y	Y		Y
Fugate (1997)	P/E	J	Exp	USA	English	G1		PO	RA	I	Y	N	N	150	Y
Gettinger (1986)	NRP	J	Exp	USA	English	Pre		PC	T	SG	Y	Y	Y		Y
Gillon (2005)	P/E	J	QED	New Zealand	English	Pre	A	C	RA	SG	Y	Y	Y	1148	Y
Hecht & Close (2002)	P/E	J	QED	USA	English	K		EC	C/T	I	Y	Y	Y		Y
Hetzroni & Shavit (2002)	P/E	J	Exp	Israel	Hebrew	GE	A	PO	T		Y	Y	N		N
Johnston & Watson (2004)	P/E	J	QED	UK	English	K	S	EC	T	WC	N	Y	Y	1600	N
	P/E	J	QED	UK	English	GE		PO	RA	SG	N	Y	N	285	Y
Justice (2000)	P/E	T/D	Exp	USA	English	Pre	A	PO	RA	SG	Y	N	N	144	Y
Kerstholt, van Bon, & Schreuder (1997)	P/E	J	Exp	Netherlands	Dutch	K			RA		N	Y	Y	120	Y
Lennon & Slesinski (1999)	NELP	J	Exp	USA	English	K	A	PO	RA	Pr	Y	Y	Y	1350	Y
	NELP	J	Exp	USA	English	K	N	PO	RA	Pr	Y	Y	Y	1350	Y
MacCoubrey (2003)	PQ	T/D	QED	Canada	English	K	A	PO	RA	SG	N	Y	Y	700	Y
McMahon, Rose, & Parks (2003)	P/E	J	QED	USA	English	G1		PO	RA	WC	Y	N	N	800	Y
Mioduser, Tur-Kaspa, & Leitner (2000)	P/E	J	Exp	Israel	Hebrew	Pre	A	EC		I	Y	Y	Y		Y
Murray, Stahl, & Ivey (1996)	P/E	J	Exp	USA	English	Pre	A	PC	T	WC	Y	N	N	150	Y
Murray (1998)	NELP	J	Exp	USA	English	K		PO	RA	Pr	Y	Y	Y	263	N
O'Brien (2006)	PQ	T/D	Exp	USA	English	Pre		H	Pt	I	N	Y	Y	490	Y
O'Connor & Jenkins (1995)	NELP	J	Exp	USA	English	K	A	PO	RA	SG	N	Y	Y	300	N
O'Connor, Notari-Syverson, & Vadasy (1996)	NELP	J	Exp	USA	English	K	A	EC	T	SG	Y	Y	Y	1200	Y
	NELP	J	QED	USA	English	K	N	EC	T	WC	Y	Y	Y	1200	Y
	NELP	J	QED	USA	English	K	A	EC	T	SG	Y	Y	Y	1200	Y
O'Connor (2000)	P/E	J	QED	USA	English		A				Y	Y	Y		Y
Oudeans (2003)	NELP	J	Exp	USA	English	K	S	PO	RA	SG	Y	Y	Y	600	N
Peterson & Haines (1992)	NRP	J	Exp	Canada	English	K	A	PO	RA	I	Y	N	N		Y
	NRP	J	Exp	Canada	English	K		PO	RA	I	Y	N	N		Y
	NRP	J	Exp	Canada	English	K		PO	RA	I	Y	N	N		Y
Putman (2005)	PQ	T/D	QED	USA	English	K		EC	T	WC	N	Y	N		Y

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Study	Source	Study type	Design	Country	Language	Age	At-risk sample	Setting	Implementer	Group size	LN	LS	PA	Time (min)	Isolated alpha
RMC Research Corporation (n.d.-a)	FCRR	R	Exp	USA	English	Pre		PC	T	WC	N	Y	Y		Y
RMC Research Corporation (n.d.-b)	FCRR	R	Exp	USA	English	K		EC	T	WC	N	Y	Y	3500	Y
	FCRR	R	Exp	USA	English	G1		EC	T	WC	N	Y	Y	3500	Y
Roberts & Corbett (1997)	P/E	R	QED	USA	English	K	M	EC	RA	WC	N	Y	Y	720	Y
Roberts (2003)	NELP	J	Exp	USA	English	Pre	A		RA	SG	Y	N	Y	1080	Y
Schneider, Roth, & Ennemoser (2000)	NELP	J	QED	Germany	German	K	A	PO	T	SG	N	Y			Y
Scott (2005)	P/E	T/D	Exp	USA	English	Pre	A	PC	T		Y	Y	Y	840	Y
Shippensburg University Research (2004)	FCRR	R	QED	USA	English	K		EC	V	I	N	Y	Y	4320	Y
Solity, Deavers, Kerfoot, Crane, & Cannon (1999)	NELP	J	QED	UK	English	K	S	EC	T	WC	N	Y	Y	5760	Y
Stuart (1999)	P/E	J	QED	UK	English	K	M	EC	T	SG	N	Y	N	3600	Y
Sumbler (1999)	PQ	T/D	QED	Canada	English	K		EC	T	WC	N	Y	Y		Y
Trout, Epstein, Mickelson, Nelson, & Lewis (2003)	NELP	J	Exp	USA	English	K	A	PO	RA	I	Y	Y	Y	4200	Y
Uhing (2005)	PQ	T/D	QED	USA	English	Pre		PO	RA	SG	Y	N	Y	1792	Y
van Bysterveldt, Gillon, & Moran (2006)	P/E	J	QED	New Zealand	English	Pre	A	H	Pt	I	Y	Y	N	240	Y
Vandervelden & Siegel (1997)	NELP	J	QED	Canada	English	K	A	PO	RA	Pr	Y	Y	Y	285	N
Vaughn et al. (2006)	C/R	J	Exp	USA	English	G1	A	PO	RA	SG	N	Y	Y	5793	Y
Walton, Bowden, Kurtz, & Angus (2001)	NELP	J	Exp	Canada	English	K/G1		PO	RA	SG	N	Y	Y	500	Y
Walton & Walton (2002)	P/E	J	Exp	Canada	English	K		PO	RA	SG	N	Y	Y	500	Y
	P/E	J	Exp	Canada	English	K		PO	RA	SG	N	Y	Y	500	Y
Whitehurst et al. (1994)	NELP	J	Exp	USA	English	Pre	A	PC	T	SG	Y	Y	Y	2063	Y
Williams (1980)	NRP	J	QED	USA	English	GE	A	EC	T	SG	N	Y	Y	2600	Y
	NRP	J	Exp	USA	English		A		T	SG	N	Y	Y	1164	Y
Woodrome (2006)	P/E	T/D	Exp	USA	English	Pre/K		RL	RA	SG	Y	N	N	120	Y
Yeh (2003)	NELP	J	Exp	USA	English	Pre	A	PC	T	SG	N	Y	Y	405	Y

Note. Components of instruction explicitly included: LN (letter name training), LS (letter sound training), PA (phonological awareness training); Time = total instruction time for the treatment group in minutes; Isolated alpha = alphabet instruction provided to the treatment group only; PQ = ProQuest; P/E = PsycInfo or ERIC database; FCRR = Florida Center for Research Research Reports; NELP = reference list from the National Early Literacy Panel review; C/R = conference presentation or other requested material; NRP = reference list from the Report of the National Reading Panel; T/D = thesis or dissertation; J = journal article; P = presentation; U = unpublished data or manuscript; R = report; Exp = experimental design; QED = quasi-experimental design; K = kindergarten; Pre = preschool; G1 = grade 1; GE = general elementary; Pre/K = mixed preschool and kindergarten; K/G1 = mixed kindergarten and grade 1; A = all; S = some; N = none; M = majority; EC = elementary school classroom; PO = pullout program; PC = preschool center; H = home; RL = research laboratory; C = clinic; RA = researcher/research assistants; T = teacher; V = community volunteer; C/T = technology such as computers or television; Pt = parent; SG = small group; I = individual tutoring; WC = whole class; Pr = pair.

Appendix B

Effect Sizes of Independent Treatment/Control Contrasts Included in Meta-Analyses

		Effect sizes for immediate outcome								Effect sizes for follow-up outcome			
Study	***N***	**LNK**	**LSK**	**LWR**	**LNF**	**LSF**	**PA**	**Read**	**Spell**	***N***	**PA**	**Read**	**Spell**
Angerilli (1999)	71		1.63*										
Aram & Biron (2004)	71	1.90*											
Aram (2006)	79	2.18*											
	77	0.13											
Ball & Blachman (1988)	89	−0.13	0.56*										
Ball & Blachman (1991)	89	−0.13	0.56*										
Bara, Gentaz, Colé, & Sprenger-Charolles (2004)	60	0.16					0.23	0.43					
Beech, Pedley, & Barlow (1994)	36		0.59	0.50									
Blachman, Ball, Black, & Tangel (1994)	159	0.28	0.62*										
Boyle (2006)	27	0.00	0.00										
Brodeur et al. (2006)	253	0.59*	0.00										
	578	0.06	0.00										
Brodeur (2007)	139	0.66*	0.75*										
	85	0.52*	0.20										
	48	0.37	−0.88*										
Caplovitz (2005)	139				0.16								
Castle, Raich, & Nicholson (1994)	28	0.28											
	48	−0.17											
Culatta, Kovarsky, Theadore, Franklin, & Timler (2003)	30	0.10					−0.98*						
de Jong, Seveke, & van Veen (2000)	27	0.43											
de Jong & Vrielink (2004)	34					−0.33		−0.31					
Edwards (2000)	64			0.91*	0.66*								
	20		1.02*	0.11									
Ehri & Wilce (1987)	18		0.95										
Eidlitz-Neufeld (2002)	242			0.47*									

		Effect sizes for immediate outcome								Effect sizes for follow-up outcome			
Study	*N*	LNK	LSK	LWR	LNF	LSF	PA	Read	Spell	*N*	PA	Read	Spell
	139		1.67*	1.09*									
	184			0.33*									
Farrell (1978)	65	0.03											
	33	0.12											
	37	−0.09											
Fuchs et al. (2001)	134					0.69*							
	134					0.49*							
	134					0.65*							
Fugate (1997)	39				0.64			0.49		39		0.25	
Gettinger (1986)	72	1.27*	2.56*										
Gillon (2005)	20		0.78										
Hecht & Close (2002)	76	−0.10	0.25	0.27									
Hetzroni & Shavit (2002)	24	1.36*	0.41										
Johnston & Watson (2004)	292		0.83*							62	−0.14	−0.05	−0.26
	62		0.32				−0.18	0.07					
Justice (2000)	30	0.46											
Kerstholt, van Bon, & Schreuder (1997)	29		2.08*										
Lennon & Slesinski (1999)	78	0.66*	0.87*										
	56	1.43*	0.60*										
MacCoubrey (2003)	71	−0.22	0.30										
McMahon, Rose, & Parks (2003)	628		0.50*				0.62*						
Mioduser, Tur-Kaspa, & Leitner (2000)	46	0.33											
Murray, Stahl, & Ivey (1996)	42	0.01											
Murray (1998)	48		−0.05										
O'Brien (2006)	37				0.36								
O'Connor & Jenkins (1995)	67				−0.47								
O'Connor, Notari-Syverson, & Vadasy (1996)	19				0.54								
	57				0.56								

		Effect sizes for immediate outcome								Effect sizes for follow-up outcome			
Study	*N*	LNK	LSK	LWR	LNF	LSF	PA	Read	Spell	*N*	PA	Read	Spell
	14				−0.12								
O'Connor (2000)	125				−1.91*								
Oudeans (2003)	54				0.00								
Peterson & Haines (1992)	16		1.06*										
	16		0.97										
	16		0.47										
Putman (2005)	24				−0.32	0.29							
RMC Research Corporation (n.d.-a)	254				0.09								
RMC Research Corporation (n.d.-b)	258				0.02								
	165				−0.10								
Roberts & Corbett (1997)	56	0.00	0.00										
Roberts (2003)	33	1.00*											
Schneider, Roth, & Ennemoser (2000)	138	0.88*					−1.00*	0.36		90	−0.58*	−0.05	−0.22
Scott (2005)	92				0.09								
Shippensburg University Research (2004)	564				0.18*								
Solity, Deavers, Kerfoot, Crane, & Cannon (1999)	433		0.86*										
Stuart (1999)	112	0.05	0.19	0.31			0.10	0.12	0.30	112	0.73*	.032	0.86*
Sumbler (1999)	265	0.19	0.96*										
Trout, Epstein, Mickelson, Nelson, & Lewis (2003)	12		1.04										
Uhing (2005)	43				−0.61*								
van Bysterveldt, Gillon, & Moran(2006)	24	−1.85*	−1.31*										
Vandervelden & Siegel (1997)	30	−0.69	1.01*										
Vaughn et al. (2006)	40	0.59	0.11		0.59								
Walton, Bowden, Kurtz, & Angus (2001)	21		0.56										
Walton & Walton (2002)	30		1.54*										
	61		0.85*										
Whitehurst et al. (1994)	167	0.39*											
Williams (1980)	102		0.63*										

		Effect sizes for immediate outcome								Effect sizes for follow-up outcome			
Study	***N***	**LNK**	**LSK**	**LWR**	**LNF**	**LSF**	**PA**	**Read**	**Spell**	***N***	**PA**	**Read**	**Spell**
	102		0.48*										
Woodrome (2006)	28	0.00											
Yeh (2003)	44		0.79*										

Note. Effect sizes significance indicates reliable difference from zero. Instruction = components of instruction explicitly included: LN (letter name training), LS (letter sound training), PA (phonological awareness training); *N* = total number of participants; LNK = letter name knowledge; LSK = letter sound knowledge; LWR = letter writing; LNF = letter name fluency; LSF = letter sound fluency; PA = phonological awareness; Read = text, word, and nonword reading; Spell = spelling.

* $p < .05$.