Decoding Skills in Children With Language Impairment: Contributions of Phonological Processing and Classroom Experiences

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Purpose: Children with language impairment (LI) often demonstrate difficulties with word decoding. Research suggests that child-level (i.e., phonological processing) and environmental-level (i.e., classroom quality) factors both contribute to decoding skills in typically developing children. The present study examined the extent to which these same factors influence the decoding skills of children with LI, and the extent to which classroom quality moderates the relationship between phonological processing and decoding.

Method: Kindergarten and first-grade children with LI (n = 198) were assessed on measures of phonological processing and decoding twice throughout the academic year. Live classroom observations were conducted to assess classroom quality with respect to emotional support and instructional support.

Results: Hierarchical regression analyses revealed that of the 3 phonological processing variables included, only phonological awareness significantly predicted spring decoding outcomes when controlling for children’s age and previous decoding ability. One aspect of classroom quality (emotional support) was also predictive of decoding, but there was no significant interaction between classroom quality and phonological processing.

Conclusions: This study provides further evidence that phonological awareness is an important skill to assess in children with LI and that high-quality classroom environments can be positively associated with children’s decoding outcomes.

Accumulating evidence suggests that both child-level and environmental-level factors are associated with word decoding ability. Specific child-level factors associated with decoding skills include phonological processing skills, which encompass phonological awareness (PA), rapid automatized naming (RAN), and verbal short-term memory (vSTM); all three have been shown to be predictive of children’s decoding skill (Barker, Sevcik, Morris, & Romski, 2013; Catts, Fey, Tomblin, & Zhang, 2002; Wagner, Torgesen, & Rashotte, 1994). An important environmental-level factor associated with decoding skills is the quality of children’s experiences in the classroom, particularly in the early primary grades; the quality of classroom instruction appears to have both direct and indirect effects on the decoding abilities of young children (e.g., Ponitz, Rimm-Kaufman, Grimm, & Curby, 2009). Some researchers have argued that literacy development among children is best represented by the interplay among child- and environmental-level factors (e.g., McGinty & Justice, 2009).

To date, there is limited evidence regarding the extent to which phonological processing and classroom quality, reflecting child- and environmental-level factors, may interact to influence the decoding skills of young children with language impairment (LI). Children with LI often exhibit phonological processing deficits (e.g., Claessen, Leitão, Kane, & Williams, 2013), and it is widely accepted that young children with LI are at risk for reading difficulties (Catts et al., 2002), particularly in word decoding (Catts, Bridges, Little, & Tomblin, 2008). Phonological processing deficits are recognized to be a core deficit among some children with LI who go on to be poor readers. It is interesting that little research has examined the way in which classroom instruction may also affect decoding skills among children with LI, although recent work indicates that children considered to be academically “at risk” have better academic outcomes when exposed to high-quality classrooms compared to children in low-quality classrooms (Hamre & Ponitz, Rimm-Kaufman, Grimm, & Curby, 2009).
Thus, we might expect that for children with LI, the relationship between phonological processing skills and decoding may vary according to the quality of the classroom environment. In the present study, we examine the extent to which phonological processing abilities and classroom quality predict year-end decoding skills for children with LI, with an interest in examining not only the unique individual influences of each but also their potential interplay.

**Phonological Processing and Decoding**

Decoding a printed, unfamiliar word involves identifying graphemes (i.e., letters or letter pairs), associating those graphemes with the relevant phonemes (i.e., speech sounds), and blending the sounds together. Not surprisingly, converging evidence from typically developing children shows that the skills underlying the processing of information about sounds, or phonological processing, are correlated with decoding ability (Catts et al., 2002; Dally, 2006; Wagner et al., 1994). The phonological processing theory of reading (Wagner & Torgesen, 1987) has garnered considerable empirical support over the years and posits that phonological processing consists of three constructs, namely PA, RAN, and vSTM, although the relative contribution of each skill to decoding remains controversial. The following paragraphs provide a brief description of each construct and an overview of the research substantiating its connection to decoding.

**PA.** PA is an umbrella term referring to one’s sensitivity to the sound structures of language (Whitehurst & Lonigan, 1998) and is often measured with tasks requiring blending, segmenting, or deletion of syllables or phonemes. PA is consistently shown to positively correlate with word decoding ability (e.g., Catts et al., 2002; Lonigan et al., 2009), although it is debated whether PA is causally related to word decoding (Castles & Coltheart, 2004; Wagner et al., 1994), or rather that PA and decoding are reciprocally related (Perfetti, Beck, Bell, & Hughes, 1987).

Regardless, a considerable body of longitudinal work has shown that measures of PA collected when children are beginning readers (e.g., kindergarten and first grade) are among the strongest predictors of later reading ability (Catts et al., 2002; Schatschneider, Fletcher, Francis, Carlson, & Foorman, 2004; Strattman & Hodson, 2005). Furthermore, as reviewed by Ehrle et al. (2001), intervention studies indicate that PA-based training programs impart positive impacts on children’s PA skills as well as their decoding skills. Thus, there is ample evidence to substantiate the important role of PA in decoding ability, to include its potentially causal role.

**RAN.** RAN tasks measure the speed at which children retrieve and name the lexical codes associated with known words, such as colors, objects, or letters. Considerable research supports the notion that RAN is a reliable predictor of decoding ability in young children (e.g., Clarke, Hulme, & Snowling, 2005; Manis, Seidenberg, & Doi, 1999). The mechanism that links RAN to decoding ability remains unclear, however. Some researchers have conceptualized RAN as an inherently phonological task (Wagner & Torgesen, 1987), such that slow RAN times reflect a specific difficulty with accessing and/or retrieving phonological representations from long-term memory, a process required when decoding unfamiliar words. Others have posited that deficits in RAN manifest from a generally inefficient timing process that is evident when children are asked to quickly associate specific visual stimuli and phonological codes (Bowers & Wolf, 1993). Although theoretical explanations for the relationship between RAN and decoding differ, some empirical evidence indicates that RAN accounts for significant and unique variance in decoding ability above and beyond PA (Clarke et al., 2005; Schatschneider et al., 2004).

**vSTM.** The third phonological processing skill theorized to associate with decoding ability is vSTM, which refers to the short-term memory storage of auditorily presented information. Studies indicate that vSTM permits readers to hold in memory the sounds of graphemes that have already been decoded in short-term memory, while continuing to decode later graphemes in a word (e.g., Gathercole, Willis, & Baddeley, 1991). As such, it is a skill that is independent from PA and RAN. Other studies have found, however, that measures of vSTM tap the same underlying phonological processing skill measured by most PA tasks (e.g., Chow, McBride-Chang, & Burgess, 2005) and that after PA has been accounted for, vSTM does not explain any additional variance (Muter & Snowling, 1998).

**Correlates of Decoding in Children With LI**

As evidenced above, the body of research supporting the relations between phonological processing and decoding in typically developing children is extensive. Studies investigating the nature of these relations in children with LI are far fewer, but accumulating evidence that these children often struggle with decoding (Catts et al., 2002; Vandewalle, Boets, Ghesquiere, & Zink, 2012) suggests this is an important area for research. Several studies have shown that compared to typically developing children, children with LI have significantly poorer performance on measures of PA, RAN, and vSTM (e.g., Claessen et al., 2013; Leitão, Hogben, & Fletcher, 1997; Vandewalle et al., 2012). For example, in a study of Dutch-speaking children, Vandewalle et al. (2012) showed that children with LI had significantly lower scores on measures of PA (both rhyme awareness and phoneme awareness) and vSTM compared to a group of typically developing children. Similarly, Claessen et al. (2013) found that children with specific language impairment (SLI; n = 21) had significantly poorer outcomes on measures of PA, RAN, and vSTM, compared to age-matched typically developing children (n = 21), although there was a wider range of ability exhibited by the children with SLI. Such evidence indicates that children with LI are likely to struggle with the primary phonological processing skills that contribute to decoding ability.
Although no studies to date have examined the unique role of each phonological processing skill to decoding in children with LI, the collective results from several studies offer conflicting evidence. For example, Catts et al. (2002) determined that in addition to letter identification, measures of PA and RAN (vSTM was not included) collected when children were in kindergarten each accounted for additional and significant variance in second-grade decoding outcomes of children with LI. Similarly, van Weerdenburg, Verhoeven, Bosman, and van Balkom (2011) found that tasks comprising a verbal-sequential processing factor, to include PA, RAN, and number recall, were most strongly predictive of word decoding in 148 Dutch children with SLI as compared to factors comprising lexical–semantic abilities, speech production, and auditory perception. However, the verbal–sequential factor was a composite of multiple phonological processing tasks, and also included measures of syntactical processing. Thus, the unique contribution of each phonological processing skill was not assessed.

Conversely, other work suggests that deficits in PA observed in children with LI are simply reflective of broader language difficulties and thus the relation between PA and decoding may be less evident. Bishop, McDonald, Bird, and Hayiou-Thomas (2009) reported that scores on RAN and vSTM tasks differentiated children with LI and decoding deficits from children in an LI-only group at age 9 years. However, PA skills, measured at ages 4 and 6 years, were not significantly different between groups. In other words, all children with LI had similarly poor PA skills, but only those with decoding problems had poorer RAN and vSTM as well. Recently, Skebo et al. (2013) found that for elementary school-aged children with speech sound disorder and concomitant LI, only scores from a standardized language assessment (i.e., the Clinical Evaluation of Language Fundamentals–Third Edition; Semel, Wiig, & Secord, 1995) was predictive of children’s decoding ability, whereas for typically developing children, PA was the strongest predictor of decoding. Therefore, the extent to which individual phonological processing skills associate with decoding may differ for children with LI compared to typically developing children.

The divergent outcomes from the studies reviewed above underscore the need for advancing our knowledge in this area for children with LI. Although there is considerable support for the notion that phonological processing skills are important for decoding success, it remains uncertain whether one or more of these phonological processing skills exerts stronger influence on decoding than others, particularly for children with LI. Examining the extent to which PA, RAN, and vSTM each uniquely influence decoding abilities in children with LI may yield important theoretical information concerning the underlying mechanisms involved in the decoding process. We may also gain clinically relevant information regarding sensitive measures to use in assessing children with language difficulties, and perhaps identify avenues for how to intervene with these children. To that end, the first aim of our study is to determine the extent to which three measures of phonological processing individually predict decoding skills in children with LI.

Classroom Effects on Decoding Skills

Given the evidence reviewed above, we would expect that proficiency with phonological processing skills will be positively associated with decoding ability in children with LI to some extent. A separate, yet complementary, body of work suggests that children’s early reading development is also influenced strongly by the nature of their experiences within the classroom (e.g., Curby, Rimm-Kaufman, & Ponitz, 2009). Indeed, it is well documented that a significant proportion of the variance in reading growth during the early primary grades reflects teacher-level effects (Nye, Konstantopoulos, & Hedges, 2004). Recent studies have shown that within the classroom context, overall quality of instruction can be captured via examination of emotional support (i.e., socioemotional climate of the classroom) and instructional support (i.e., the teacher’s incorporation of higher order thinking, language modeling, and feedback to students in teacher–student interactions).

The extant literature suggests that the quality of both emotional and instructional classroom support in primary grade classroom environments is associated with children’s decoding growth over time (Burchinal et al., 2008; Connor, Son, Hindman, & Morrison, 2005). The positive association between quality of classroom instruction and children’s achievement results from the highly malleable nature of decoding skills during the early primary grades (Foorman, Francis, Fletcher, Schatschneider, & Mehta, 1998) and variations in the extent to which these skills are fostered in these settings (Kent, Wanzek, & Otaiba, 2012). Some studies suggest, surprisingly, that emotional support within primary-grade classrooms is more influential to children’s decoding growth than instructional support. For instance, Connor et al. (2005) showed that children in emotionally supportive classrooms, as measured by teachers’ warmth and responsiveness, had stronger decoding skills at the end of first grade than children whose teachers had lower scores on teacher warmth and responsiveness. Similarly, Curby et al. (2009) found significant and positive relations between emotional support and first graders’ PA. Specifically, children in classrooms rated as having high emotional support were more likely to have higher levels of PA. It is interesting that their results also showed moderating effects of instructional support on children’s initial skill levels, such that children with lower abilities benefitted most in classrooms that were highly rated for instructional support. One possible reason that emotional support is more directly linked to decoding outcomes compared to instructional support is that in the early elementary school years, the observed level of emotional support tends to exceed that of instructional support (e.g., La Paro et al., 2009), in both kindergarten and first grade classrooms (Curby et al., 2009). Thus, it is similarly possible that children with LI, who often exhibit...
differences with phonological processing and decoding tasks, might markedly benefit from being in high-quality classrooms offering strong emotional support, during the early primary grades.

Taken together, these studies indicate that children whose learning occurs in high-quality classroom environments may be in an advantaged position with respect to decoding development as compared to children in lower quality environments. This outcome has been seen in typically developing children as well as those considered at risk for academic problems; however, to our knowledge there is no evidence that has specifically examined the influence of classroom quality on decoding skills for children with LI. Because school-age children with LI are at an increased risk for decoding deficits, it is critical to understand the ways in which the classroom environment may affect this essential aspect of early reading, and the extent to which classroom quality may moderate the relationships between children’s initial phonological processing skills and later decoding ability.

**Purpose of the Present Study**

To sum, prior research substantiates the notion that decoding involves three primary constructs of phonological processing (i.e., PA, RAN, and vSTM). Although data from children with LI validate this theory to some degree, the extent to which each of these constructs contributes uniquely to their decoding ability is not clear. Similarly, the effects of classroom quality (i.e., emotional and instructional support), both of which have been shown to positively affect decoding skills for children with typical language skills, have not been previously investigated in children with LI. Prior research suggests that emotionally supportive classroom environments may be particularly important for growth in early reading. To increase our understanding of the antecedents of decoding skill among children with LI, giving attention to both child- and environmental-level factors, the present study addressed the following three research questions: (a) To what extent do phonological processing abilities predict decoding skills in children with LI? (b) To what extent does classroom quality predict decoding skills in children with LI? (c) To what extent is the relation between phonological processing and decoding among children with LI conditional on the quality of classroom instruction?

**Method**

**Participants**

Participants were drawn from a larger, multicohort study (Speech Therapy Experiences in the Public Schools [STEPS]) that involved 292 children receiving speech-language therapy within public schools in the Midwestern and Mid-southern regions of the United States. The children were nested in the caseloads of 73 speech-language pathologists (SLPs) in public-school settings (range two to five children per SLP caseload). The data for each cohort were collected over the course of one academic year (2009–2010, 2010–2011, and 2011–2012).

The children in the STEPS database are best described as a clinically identified sample of children with LI, in that each child was eligible for speech-language services and had one or more language goals on his or her Individualized Education Plan; each was receiving direct services from an SLP within the child’s public school. In the fall of the academic year, participating SLPs were asked to identify up to 10 children on their caseload given the following broad criteria: (a) demonstrated a primary LI, (b) exhibited normal hearing, (c) did not demonstrate severe cognitive impairment, and (d) were in kindergarten, first, or second grade. The families of these children received information about the study and could consent for their child to participate.

Only those children who had a full data set specific to the variables used in this study and were in kindergarten or first grade (n = 249) were selected from the STEPS database to be included in the present study (representing 85% of the sample). The children were administered the Core Language subtests of the Clinical Evaluation of Language Fundamentals–Fourth Edition (CELF-4; Semel, Wiig, & Secord, 2003) as an index of spoken language skill and the Kaufman Brief Intelligence Test–Second Edition (Kaufman & Kaufman, 2004) as a measure of nonverbal cognition in the fall of the academic year, independent of any tests administered by their SLP. Because the present study concerned children with identifiable language deficits in the absence of severe cognitive difficulties, we excluded those whose Core Language composite scores were 86 or above (n = 42) and those whose Kaufman Brief Intelligence Test–Second Edition scores were below 70 (n = 9). The 198 remaining children included 72 girls and 126 boys and had a mean age of 76.08 months (SD = 8.45). Complete data regarding participant characteristics and demographic information are provided in Table 1.

**Procedure**

Procedures relevant to the present study included assessment of children’s language and decoding-related skills (fall and spring), and completion of a classroom observation (winter). Children completed a battery of language and decoding-related assessments in the fall and spring of the academic year; the battery was identical at both time points. At each testing time point, all children were assessed within a 6-week time frame (September–October; April–May). Each testing session lasted approximately 45 minutes, and was administered by trained research staff in a quiet location within the child’s school. Prior to testing children, all assessors completed an online training module for each of the study measures, scored at least 80% on a test-administration quiz, and participated in a mock assessment, for which they received feedback. All child-level assessment data were double-scored, with conferencing for any disagreements, and all data were double-entered (the second entry superimposed over the initial entry, in which disagreements were flagged by the software) to ensure accuracy of data.
In the winter of the academic year, research staff conducted a 60-minute classroom observation (kindergarten, \( n = 82 \); first grade, \( n = 116 \)). Details of the observation coding scheme and reliability procedures are described below.

**Measures**

Three measures were used to address the study’s main research questions: (a) children’s phonological processing and decoding in the fall of the year, (b) children’s decoding scores in the spring of the academic year, and (c) observation of each participating child’s classroom quality.

**Fall phonological processing and decoding skills.** In the fall of their academic year, children were assessed on a battery of phonological processing and decoding skills.

**Phonological processing.** The three constructs of phonological processing were measured with (a) a phonological deletion task (PA), (b) RAN of shapes and colors (RAN), and (c) a number repetition and sentence imitation task (vSTM). The PA task used was the Catts Deletion Task (Catts, Fey, Zhang, & Tomblin, 2001). This test assesses a child’s ability to delete phonological structures of varying size (word, syllable, and phoneme) from a larger word. There are a total of 21 items, and responses are scored as either correct (1) or incorrect (0).

RAN was tested with the Shapes and Colors subtest of the CELF-4, which required that children name visually presented shapes and colors and shape–color combinations while being timed. All stimuli were presented in a 6 × 6 grid. Children were timed as they named the colors and shapes (e.g., blue circle), and the total number of errors were also recorded. For the present study, only the total naming time, in seconds, was used in the analyses. Test–retest reliability for RAN naming time is .87.

Two measures of vSTM were included: (a) the Number Repetition subtest of the CELF-4 and (b) the Recalling Sentences subtest of the CELF-4, both of which have been previously used to assess verbal memory (Gabig, 2008; Wagner et al., 1994). The Number Repetition subtest requires children to repeat auditorily presented lists of digits in forward order. With each test item, the number of digits to recall increases by one. The Recalling Sentences subtest requires children to repeat auditorily presented sentences verbatim. The sentences increase in both length and grammatical complexity. For all CELF-4 subtests, scaled scores were calculated by summing scores on each subtest and transferring the raw score to the scaled score listed in the manual. Internal consistency reliability for the Recalling Sentences subtest is .91 and for the Number Repetition subtest was .79.

**Fall decoding.** Fall decoding ability was measured with the Word Attack (WA) subtest of the Woodcock-Johnson III Tests of Achievement (Woodcock, McGrew, & Mather, 2001). W scores are calculated based on Item Response Theory, which makes score increments equal intervals. This allows the scores to be both comparable and interpretable in statistical analyses. The WA subtest required that children decode lists of increasingly complex nonwords. Test–retest reliability for children ages 4 to 7 years for the WA subtest is .79.

**Spring decoding.** In the spring of their academic year, children were assessed on the same battery of phonological processing and decoding skills. However, the outcome measure relevant to the present study was only the measure of spring decoding ability, comprising W scores from the WA subtest of the Woodcock-Johnson III Tests of Achievement.

**Classroom quality.** An overall measure of classroom quality was obtained via direct observations conducted in each child’s classroom using the Classroom Assessment Scoring System (CLASS; Pianta, LaParo, & Hamre, 2008). The CLASS examines 10 unique dimensions of classroom quality that reflect three domains (Hamre & Pianta, 2005). Specifically, the dimensions of Positive Climate, Negative Climate, Teacher Sensitivity, and Regard for Student Perspective comprise the domain of Emotional Support; the

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**Table 1. Participant characteristics and demographic information**

<table>
<thead>
<tr>
<th>Variable</th>
<th>( n )</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>76.08</td>
<td>8.45</td>
</tr>
<tr>
<td>Range</td>
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</tr>
<tr>
<td>Grade</td>
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<td></td>
</tr>
<tr>
<td>Kindergarten</td>
<td>82</td>
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<tr>
<td>First grade</td>
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<td>58.6</td>
</tr>
<tr>
<td>Gender</td>
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<td></td>
</tr>
<tr>
<td>Male</td>
<td>126</td>
<td>63.6</td>
</tr>
<tr>
<td>Female</td>
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</tr>
<tr>
<td>Highest level of maternal education</td>
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<td></td>
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<tr>
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<tr>
<td>Not reported</td>
<td>46</td>
<td>23.2</td>
</tr>
<tr>
<td>Cognitive ability</td>
<td></td>
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<tr>
<td>( M )</td>
<td>87.44</td>
<td></td>
</tr>
<tr>
<td>SD</td>
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<td>( M )</td>
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<tr>
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</table>

Note. Cognitive ability represents standard scores from the Kaufman Brief Intelligence Test–Second Edition (Kaufman & Kaufman, 2004) Matrices subtest where the mean = 100 and one standard deviation = 15; Language represents standard scores from the Core Language composite of the Clinical Evaluation of Language Fundamentals–Fourth Edition (Semel, Wig, & Secord, 2003) where the mean = 100 and one standard deviation = 15. \( M \) = mean; \( SD \) = standard deviation.
dimensions of Concept Development, Quality of Feedback, and Language Modeling comprise the domain of Instructional Support; and the dimensions of Behavior Management, Productivity, and Instructional Learning Formats comprise the domain of Classroom Organization. Classroom Organization does not typically associate with children’s reading skills (Curby et al., 2009). Thus, the present study only examined the effects of emotional support and instructional support on the decoding skills of children with LI.

Trained coders conducted live classroom observations during which they rated each classroom along the 10 dimensions during four consecutive cycles of 12 to 15 minutes, for a total observation period of 48 to 60 minutes. During each cycle, each CLASS dimension was coded on a scale of 1 to 7, such that higher numbers correspond with higher quality, with the exception of one dimension that was reverse-scored.

Project staff who coded classroom observations using CLASS had previously completed a 2-day comprehensive training program. In order to pass CLASS training, all coders had to achieve 80% reliability across all dimensions and domains. That is, all coders had to achieve 80% agreement (within one point of the master code) with five master-coded videos before they could code on their own. Subsequently, all CLASS-coders participated in bimonthly drift meetings to recalibrate their coding skills. Overall interrater agreement, within one point, was 94%, which is comparable to interrater reliability statistics reported by other studies utilizing the CLASS for classroom observations (e.g., Curby et al., 2009).

Results

Preliminary Analyses

Descriptive data for children’s fall phonological processing and decoding skills and spring decoding scores, in addition to the mean composite scores for classroom quality, are presented in Table 2. Correlations among the key study variables appear in Table 3 and are depicted in Figure 1. These data indicate that all phonological processing measures were moderately to strongly correlated with fall decoding scores and spring decoding scores. In Figure 1, the distribution of PA has a noticeable floor effect, suggesting that the task may have been too difficult for the participants. The following analyses that use PA as a predictor may consequently result in an underestimation of the importance of PA in its relation to decoding. Previous research has shown that children’s initial decoding ability is a strong predictor of future decoding skills (e.g., Catts et al., 2002; Connor, Morrison, & Katch, 2004). As expected, children’s fall decoding scores were significantly correlated with their spring decoding ability ($r = .665$, $p < .001$), and the subsequent regression analyses controlled for fall decoding. Because of the age range in the present sample, age in months was also included as a control variable.

We also examined the extent to which children’s decoding skills changed over the course of an academic year. The decoding scores of children from the fall of their school year were compared to scores in the spring of that same school year. A paired samples $t$-test revealed that children’s decoding scores (W scores) were significantly higher in the spring ($M = 441.73$, $SD = 26.71$) than in the fall ($M = 419.21$; $SD = 29.45$), $t(197) = -13.80$, $p < .001$, indicating that children’s decoding skills increased as the school year progressed.

Phonological Processing Predictors of Decoding

Our first research question focused on the extent to which three separate constructs of phonological processing (i.e., PA, RAN, and vSTM) account for children’s decoding skills at the end of the academic year. We included one measure of PA (i.e., phonological deletion), one measure of RAN (i.e., colors and shapes), and two measures of vSTM.
(i.e., Number Repetition and Recalling Sentences) as predictors of spring decoding skill, using hierarchical multiple regression analyses with children’s spring decoding scores as the outcome variable. In all models, we controlled for fall decoding scores and age (in months) and the predictor variables were grand mean-centered.

Results of the regression analyses, presented in Table 4, show that fall decoding scores predicted 43.7% of variance in spring decoding scores. Adding the phonological processing variables into the model explained an additional 3.7% of variance, although the only significant phonological processing variable was PA ($p = .002$). The measures representing RAN ($p = .133$) and vSTM (i.e., Number Repetition and Recalling Sentences; $p = .774$, $p = .582$) were not significant predictors of spring decoding skills in children with LI.

Classroom Predictors of Decoding

Our second research question examined the extent to which classroom quality, comprising both emotional and instructional support of children’s kindergarten or first-grade classrooms, exerted unique influence on children’s decoding skills. To address this question, a third block of variables pertaining to observed classroom quality (emotional support and instructional support) was added to the model (see Table 4); thus, classroom-level effects were examined when controlling for the phonological processing variables. The results of this analysis showed that emotional support, one index of classroom quality, was a significant predictor of children’s decoding skill ($p = .010$), accounting for an additional 1.9% of variance in the outcome.

The third research question considered the extent to which the relations between phonological processing and decoding might be conditional upon the quality of classroom instruction. As PA was the only significant phonological processing variable contributing significantly to children’s decoding skills, interaction terms between emotional support and PA and between instructional support and PA were entered as a fourth block in the model. In this fourth step of the regression analysis, neither interaction term accounted for a significant amount of additional variance in children’s spring decoding outcomes ($p = .33$). Finally, we considered the possibility that the effects of emotional support might be dependent upon levels of instructional support, and that interaction effects between these two aspects of classroom quality would account for additional variance. The interaction terms between emotional support and PA and between

Figure 1. Histograms and scatterplots of correlations between phonological processing predictors and fall and spring decoding scores. PA = phonological awareness (Catts deletion task); RAN = rapid automatic naming of objects and colors (Clinical Evaluation of Language Fundamentals—Fourth Edition [CELF-4]); NR = Number Repetition Forward (CELF-4); RS = Recalling Sentences (CELF-4). Fall WA = W scores from the Word Attack subtest of the Woodcock-Johnson III Tests of Achievement administered in the Fall; Spring WA = Word Attack subtest of the Woodcock-Johnson III Tests of Achievement administered in the Spring.
support.

ES = classroom emotional support; IS = classroom instructional support.

Repetition Forward (CELF-4); RS = Recalling Sentences (CELF-4); Language Fundamentals automatic naming of objects and colors (Clinical Evaluation of

PA = phonological awareness (Catts deletion task); RAN = rapid automatic naming of objects and colors (Clinical Evaluation of Language Fundamentals–Fourth Edition [CELF-4]); NR = Number Repetition Forward (CELF-4); RS = Recalling Sentences (CELF-4); ES = classroom emotional support; IS = classroom instructional support.

Step 4:

Age .110 .201 .035 .551
Fall WA .487 .058 .538 8.363***
PA .709 1.981 .019 1.059
RAN .034 .025 .073 .130
NR .550 .025 .037 .996
RS .378 .685 .035 .552
ES 6.493 2.504 .156 2.593*
IS −1.114 1.631 −0.043 −0.701

Step 5:

Age .188 .229 −.143 −.787
Fall WA .487 .058 .538 8.363***
PA .709 1.981 .019 1.059
RAN .034 .025 .073 .130
NR .550 .025 .037 .996
RS .378 .685 .035 .552
ES 6.493 2.504 .156 2.593*
IS −1.114 1.631 −0.043 −.701

Note.  SE, standard error; Fall WA = W scores from the Word Attack subtest of the Woodcock-Johnson III Tests of Achievement; PA = phonological awareness (Catts deletion task); RAN = rapid automatic naming of objects and colors (Clinical Evaluation of Language Fundamentals–Fourth Edition [CELF-4]); NR = Number Repetition Forward (CELF-4); RS = Recalling Sentences (CELF-4); ES = classroom emotional support; IS = classroom instructional support.

*p < .01, **p < .001, ***p < .001.

instructional support and PA were removed from a fourth block in the model and placed with an interaction term between emotional and instructional support. However, this term did not account for additional variance in children’s spring decoding outcomes either (p = .73). Consequently, there was no observed interplay among the child- and environmental-level variables examined in this work with respect to predicting children’s decoding skills.

Discussion

The present study adds to a growing body of research suggesting that both PA skills and aspects of classroom quality are uniquely and significantly associated with the decoding abilities of children with LI. To date, research examining the predictors of decoding in children with LI has offered either conflicting or insufficient evidence concerning the extent to which the three components of phonological processing (viz., PA, RAN, and vSTM) account for unique and significant variance in decoding skills. In addition, previous work had largely ignored the potential relations between classroom quality and decoding skills in children with LI, despite a considerable body of research highlighting the importance of emotional and instructional classroom support for typically developing children. Results of the present study showed that only PA was significantly predictive of year-end decoding skills, although all phonological processing variables were correlated. Furthermore, children’s spring decoding skills showed important linkages to classroom quality, specific to the level of emotional support. We discuss these findings in greater detail, and offer possible explanations for these results, in the following paragraphs.

Phonological Processing and Decoding in Children With LI

The first major finding of the present work was demonstration that PA was a significant predictor of spring decoding skills, even after controlling for fall decoding ability, among primary-grade students with LI. This is especially salient in light of the floor effect observed for PA, which underestimates the strength of the prediction (Cohen, Cohen, West, & Aiken, 2002). The predictive value of PA to decoding is a consistent outcome for children within a wide range of cognitive and communication abilities, including those with typical language skills (e.g., Barker et al., 2013; Catts et al., 2002; Skebo et al., 2013). Children who exhibit difficulty recognizing and manipulating the individual phonological structures of language are likely to exhibit related difficulty with the phonological decoding of words. Thus, the present study converges with the extant literature in showing that PA is a significant predictor of word decoding ability in children with LI.

Importantly, however, our study showed that of the three components of phonological processing, only PA was significant in predicting children’s spring decoding skills. Although our results are consistent with studies showing that both RAN and vSTM correlated with decoding ability, our analyses showed that neither RAN nor vSTM accounted for significant variance in spring decoding. In that respect, our data diverge from a number of studies to date that have demonstrated a predictive relationship between RAN and vSTM skills and word decoding (Bishop et al., 2009; Manis et al., 1999). Although this was an unexpected outcome, there are a few plausible interpretations. First, with respect to RAN, it is possible that for children with LI, the stimulus prompts for the RAN task in this study (i.e., colors and shapes) are not as strongly associated with decoding ability as the rapid automatic naming of letters, for example. Evidence exists to suggest that RAN of nonalphabetic stimuli is predictive of reading (e.g., Lervåg & Hulme, 2009), but it has also been argued that RAN of letters is more reflective of the actual process of decoding (e.g. Schatschneider et al., 2004). Schatschneider et al. (2004), for example, found that kindergarden measures of RAN of letters were a stronger predictor
of decoding as compared to RAN of objects. Further, Mazzocco and Grimm (2013) reported that children classified as “low achievers” in reading differed from children with age-appropriate reading skills on RAN tasks of letters and digits, but not on a RAN colors subtest. Thus, it is possible that a RAN of letters task would have borne a more directly predictive relation to decoding outcomes for the children with LI in this study. This warrants future examination.

A second explanation comes from studies suggesting that RAN is only predictive of decoding ability at specific stages of reading achievement, although the precise time point of significance is unclear. Some researchers have argued that RAN appears to be primarily associated with reading in the early stages (Chow et al., 2005; Wagner et al., 1994), whereas conflicting evidence has shown that the relationship between RAN and decoding strengthens as children become more proficient readers (e.g., Meyer, Wood, Hart, & Felton, 1998). Thus, it is possible that for early readers with LI, the ability to rapidly name colors and objects at the beginning of the academic year was not indicative of their ability to decode words by the end of the school year, and that concurrent or later assessments might have yielded different results. As noted earlier, it is not entirely clear if the relations between RAN and decoding that are often reported in the literature result from both tasks involving some degree of phonological processing or from both tasks requiring the ability to quickly link visual and linguistic information. Data from the present study did not align with either explanation, and may instead indicate that children with LI process language in a qualitatively different way than typically developing children and that, in turn, they may rely on a different set of skills for word decoding. It is outside the scope of this work to speculate further; however, future studies might seek to replicate the findings from the present study and include additional phonological processing tasks to better understand the variables that are most closely related to decoding ability in children with LI.

Our study also failed to find a significant predictive relationship between vSTM and decoding. This outcome accords with some prior work examining unique contributions of phonological processing skills, in which the variance accounted for by vSTM is minimal (e.g., Chow et al., 2005; Dally, 2006). Specifically, Dally (2006) argued that because success on PA tasks is at least partially dependent upon memory storage capacity for phonologically based information, any variance in decoding that might be attributed to vSTM would be incorporated by PA. It is interesting that Chow et al. (2005) found that although RAN was a concurrent predictor of word reading in Chinese- and English-speaking children, RAN did not predict future word reading skills. Similarly to results reported in the present study, Chow et al. (2005) reported that only PA accounted for significant variance in word reading skills at the end of the year.

Our finding that only PA emerged as a significant predictor could also be considered from another theoretical perspective. Although numerous studies have tested the phonological processing theory of decoding by examining the unique influences of the three core phonological processing skills, Clarke et al. (2005) suggest there is utility in considering these skills dichotomously, as explicit and implicit phonological processing skills. Tasks measuring RAN and vSTM do not require active attention to the phonological components of the measure, and would thus be considered implicit phonological processing skills. Tasks tapping PA are inherently metalinguistic, which necessitates an awareness of and knowledge about sound structures, and would thus be considered an explicit phonological processing skill. As described earlier, children with LI have been shown to exhibit deficits in both implicit and explicit phonological processing skills. Perhaps for children with overall depressed phonological processing skills, the ability to decode words is more heavily predicated upon the mechanism underlying explicit phonological processing.

**Classroom Quality and Decoding in Children With LI**

The early elementary classroom is the context in which kindergarteners and first-grade children learn to decode written words. Considerable evidence, largely drawn from typical readers, shows that differences in classroom quality influence children’s reading development (Nye et al., 2004). The present study is one of the first efforts of which we are aware to examine linkages between decoding skill and classroom quality for children with LI. Of the two classroom quality dimensions we investigated, the level of emotional support, but not instructional support, was a significant predictor of children’s spring decoding skills. Importantly, emotional support explained additional variance in predicting spring decoding skills, even after accounting for prior decoding abilities and PA.

This finding converges with prior studies in two ways. First, the descriptive results concerning the composite scores of emotional support and instructional support are very similar to previous studies examining kindergarteners and first-grade classroom environments (e.g., Curby et al., 2009; Pianta, Belsky, Vandergrift, Houts, & Morrison, 2008) in that the level of emotional support is greater than that of instructional support. Second, our data align with previous work in showing that high-quality emotional support in the classroom can positively impact the decoding outcomes of typically developing children (Connor et al., 2005). The present study extends these findings to capture the schooling experiences of children with LI. Ours is not the first study to find significant effects for emotional support but not instructional support; perhaps for very young children in the earliest stages of reading that particular aspect of classroom quality is of specific importance. Theories of social-motivational processes may offer some explanation for why emotional support would be associated with the decoding skills of children with LI. Work by Wentzel (1998), for example, found a positive correlation between students’ perceived levels of teacher support and interest in academic activities and in achieving classroom goals. The dimension of emotional support captured in the present study measures...
the overall emotional climate of the classroom, teacher sensitivity to students, and teacher responsiveness to students' needs and perspectives. We might theorize that instruction provided in an environment that is positive, warm, and attentive to children's individual and academic needs may make it easier for children with language difficulties to remain focused and attentive. If that is the case, our data support the idea that for children with LI, the emotional quality of the classroom is a stronger predictor of children's decoding outcomes compared to instructional quality. Therefore, our findings do not necessarily suggest that instructional support is unimportant; rather, our work converges with previous research to suggest that the emotional climate of the classroom may offer a particularly powerful source of support and strength for children with LI.

It was somewhat surprising that the interaction between classroom quality and children's individual skills were not significant, because we had hypothesized classroom quality to function as a conduit for instructional effects on children's outcomes. It is unclear why our findings diverge from that of Hamre and Pianta (2005), which showed that classroom quality indeed moderated the relation between children's "functional risk" status in kindergarten (as measured by both socioemotional and academic performance) and a broad measure of first grade academic achievement. However, it should be noted that different predictor and outcome variables were utilized in the present study, and the population under investigation varied as well. Thus, it is possible that the skill domain assessed in the present study was too narrow, and that the influence of PA on decoding did not vary according to the instructional or emotional quality of the classroom environment.

Limitations and Conclusions

Some limitations of this study bear consideration. First, although we aimed to examine the relations between three individual phonological processing constructs and decoding, we utilized only one observed variable for RAN. Thus, we were not able to explore the extent to which other RAN tasks might evidence a stronger relationship with decoding than that of colors and shapes. Future research should continue to investigate the relation between naming speed and decoding in children with LI and the extent to which this may differ with other stimuli.

Second, in order to examine the influence of classroom support, we utilized two broad dimensions of instructional and emotional support, drawn from approximately 1 hour of observed classroom time per child, which may or may not have coincided with decoding-related instructional time. In addition, these data were drawn from one live classroom observation per child; thus, the extent to which teachers may have altered their teaching style on observation days could not be assessed. However, because the range of scores for both aspects of classroom quality are so similar to those reported in previous research (e.g., Curby et al., 2009; Pianta, Belsky, et al., 2008), it is unlikely that our results were skewed by observer effects. Still, future studies should consider alternative ways of measuring these two important aspects of classroom quality. Future work should also aim to specifically evaluate the influence of decoding-related instructional practices on children with LI in order to draw stronger conclusions regarding the effects of instructional support for this particular population.

Finally, as with most large samples of children with LI, the participants in the present study represented a rather heterogeneous group of children in terms of their phonological processing and decoding abilities. Although we incorporated additional exclusionary criteria to more tightly define our sample, we did not have information about their speech sound production skills, which may additionally have interacted with language skills and altered the observed relations between phonological processing and decoding.

In sum, our findings add significantly to the body of research focused on understanding the multiple sources of influence on early decoding skills in young children with LI. Although previous research concerning children with LI often indicates a phonological processing deficit, the present work is the first to investigate the unique contributions of the three phonological processing variables theorized to predict decoding ability. Our results support the body of work showing that PA is a predictor of word decoding skills in children with LI (e.g., Catts et al., 2002; van Weerdenburg et al., 2011), but the present data diverge from some previous work in that neither RAN nor vSTM accounted for any unique variance in decoding. As such, future work is warranted to both replicate and further explore these findings. Importantly, the present work also reflects the first effort to examine the effects of classroom quality for children with LI. Results reported here mirror those from studies of typically developing children in that emotional support within the context of the classroom environment accounts for additional and significant variance in decoding. Taken together, these data indicate that the processing of phonological information for decoding may differ in some ways for children with LI from what has been previously observed in typically developing children, but that emotional support within the context of the classroom environment offers a unique and positive source of influence toward decoding abilities. Overall, these results provide a positive outlook with respect to supporting the decoding skills in children with LI because PA is a skill that can be explicitly targeted and can improve. Similarly, there is evidence that teachers can actively monitor and adjust their levels of emotional support in the classroom (e.g., Sawka, McCurdy, & Mannella, 2002). Thus, future work must focus on more fully exploring the nature of the relationship between classroom quality and decoding and maximizing the potentially positive sources of influence for reading growth in children with LI.

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References


