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Do Spelling and Vocabulary Improve Classification Accuracy of Children's Reading Difficulties Over and Above Word Reading?

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ABSTRACT

It is widely recognized that individuals with dyslexia have difficulties with word reading *and* spelling, and individuals with reading comprehension difficulties have low vocabulary knowledge. However, little is known about the extent to which spelling and vocabulary are informative of reading difficulties. In the present study, we investigated whether information on students' spelling and vocabulary in kindergarten increases the precision of identifying students with reading difficulties, using longitudinal data from kindergarten to Grade 2. The sample was composed of 247 kindergartners (55% boys; 56% White children, 35% African American children, and 5% mixed-race children; 72% from low SES) who were followed to Grade 2. Spelling improved the accuracy of identifying students who experienced word reading difficulties in kindergarten and Grade 1. In contrast, vocabulary did not improve the accuracy of identifying students with reading difficulties over and above word reading and spelling. These results indicate the importance and utility of including spelling, in addition to word reading, as an integral part of accurately identifying children with reading difficulties as early as kindergarten. In addition, although vocabulary did not contribute additional predictive power, it is likely to exert its influence at a later phase of reading development.

Early Identification of Reading Difficulties

One of the issues plaguing the field of literacy is what is called the "dyslexia paradox" (Ozernov-Palchik & Gaab, 2016). This refers to the discrepancy between when students are typically identified with dyslexia and the ideal time for intervention: Reading interventions are more effective in early primary grades such as kindergarten and Grade 1 than in later grades (see a meta-analysis by Wanzek et al., 2016), but students are not typically identified with reading difficulties including dyslexia until later grades. Late identification is problematic as it misses a critical window of time when students are developing foundational reading skills (primary grades) and associated opportunities to provide intensive instructional support to mitigate and prevent reading difficulties. Crucial in addressing the dyslexia paradox is an accurate identification of students who are at risk of reading difficulties early in kindergarten. In fact, early identification as part of a systematic approach to addressing instructional needs is the crux of the multi-tiered systems of supports (MTSS) framework (Al Otaiba et al., 2014; Fletcher et al., 2020) and prevention models in reading (e.g., Catts & Hogan, 2021; Catts & Petscher, 2022). In these approaches, students are screened and identified for their strengths and needs as early as possible and are provided with appropriate instruction starting with solid core (tier 1) instruction accompanied by intensive

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support depending on students' needs and progress (e.g., tier 2 instruction).

High-quality screening is part and parcel of the MTSS framework and early identification of students who are at risk of reading difficulties (Catts et al., 2001; Torgesen, 2009). With renewed attention to and interest in dyslexia and associated legislations in the vast majority of states in the United States (see https://improvingliteracy.org/state-of-dyslexia), screening is widely available in US contexts. For example, according to the National Center on Intensive Intervention (https://intensiveintervention.org/), widely used assessment batteries include word reading as well as precursors of word reading skills such as letter knowledge, phonological awareness, and phonological decoding (nonsense/pseudoword word reading). Importantly, several widely used assessments (e.g., FastBridge, Lexia RAPID assessment, MAP, PALS) also include spelling and/or vocabulary.

Spelling and Reading

Spelling refers to the ability to encode words according to the orthographic system of a language. According to the interactive dynamic literacy model (Kim, 2020a, 2022), word reading and spelling are closely linked skills (also see Ehri, 1997; Perfetti, 1997; Treiman, 1993) because both word reading and spelling involve highly similar processes and draw on identical skills. For example, to read the word *cat* as /kæt/, the child has to recognize and retrieve the letters, retrieve sounds associated with each letter, and assemble and blend the sounds in the correct order. To accurately spell the word *cat*, the child needs to have an accurate representation of the sounds in a target word, /kæt/, and retrieve graphemes associated with each identified phoneme, followed by selecting correct graphemes, assembling them in the correct order, and forming letters accurately. In languages that employ the morphophonological writing system (e.g., English), these processes draw on knowledge and awareness of phonology, orthography, and morphology because graphs principally represent phonemes and morphemes (Adams, 1990; Apel & Apel, 2011; Silliman et al., 2006; Treiman, 1993). The lexical quality hypothesis (Perfetti, 2007) similarly underscores the quality of a mental representation of a word's orthographic and phonological forms and meanings as a key foundation. Therefore, knowledge and awareness of phonological structures (phonological awareness), graphemes and their mapping to phonemes (orthographic awareness), and morphological structures and their mapping to graphemes (morphological awareness) are key to word reading and spelling acquisition (Adams, 1990; Castles et al., 2018; Rayner et al., 2001). Indeed, a rich body of research has confirmed their roles in word reading (e.g., Adams, 1990; National Early Literacy Panel [NELP], 2008; National Institute of Child Health and Human Development, 2000) and spelling (e.g., Bourassa et al., 2006; Caravolas, 2004; Kim et al., 2013; NELP, 2008; Silliman et al., 2006; Treiman, 1993).

Evidence has supported a strong relation between word reading and spelling skills (r = .82; see Kim et al., 2023, for a meta-analysis). One corollary of their strong relation is the co-occurrence of word reading and spelling difficulties (Hebert et al., 2018; Kim, 2020a, 2022). A robust body of evidence indicates that students with word reading difficulty experience spelling difficulty and vice versa (e.g., Berninger et al., 2008; Bourassa & Treiman, 2003; Cassar et al., 2005; Graham et al., 2021; Kemp et al., 2009; Lefly & Pennington, 1991; Lipka et al., 2006; Manis et al., 1993; Scarborough, 1998). Further evidence on the word reading-spelling relation comes from intervention literature: Spelling intervention improves word reading (e.g., Berninger et al., 1998; Galuschka et al., 2020), word reading intervention improves spelling skills (e.g., Hatcher et al., 2006; Simmons et al., 2007), and integrated instruction of word reading and spelling improves both (Graham et al., 2017). Perhaps not surprisingly, spelling difficulty is recognized as one of the key symptoms of dyslexia according to the International Dyslexia Association and the Rose report (2009).

Despite a strong relation between word reading and spelling, word reading and spelling are not identical skills. Studies have shown that word reading and spelling skills are dissociable for students learning to read and spell in shallow orthographies (Gangl et al., 2018; Moll et al., 2020; Moll & Landerl, 2009; Papadopoulos et al., 2020; Torppa et al., 2017; Wimmer & Mayringer, 2002) and deep orthographies (Fayol et al., 2009; Furnes et al., 2019; Holmes & Quinn, 2009; Lee & Al Otaiba, 2017). In most languages with alphabetic writing systems, phoneme-grapheme correspondences are less consistent than grapheme-phoneme consistency (Moll & Landerl, 2009). Furthermore, reading words is a receptive skill, whereas spelling words is a productive skill, and spelling words requires greater precision in knowledge and representation in memory than reading words (Ehri, 1997). Accurate word reading can be achieved using partial cues or incomplete mental representations of word spellings, whereas this does not lead to successful spelling of words. For example, in word reading, the child can accurately read the words *bird*, *burn*, and *fern* by recognizing that *ir*, *ur*, or *er* graphemes make the same /ɚ/ sound. In contrast, spelling requires retrieval of word-specific graphemes (e.g., selecting *ir*, *er*, or *ur* for the /ɚ/ sound depending on the word). Therefore, spelling reflects words' phonological, orthographic, and morphological/semantic information and lexical representations of words more precisely than word reading (Ehri, 2000; Frith, 1980; Perfetti, 2007). This has been supported in empirical studies. For example, kindergartners who were provided with systematic and explicit instruction on invented spelling improved their word reading (Ouellette & Sénéchal, 2008), and when students were trained on spelling, their word reading speed was faster for words that improved in spelling accuracy than those that did not show improvement in

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spelling (Ouellette et al., 2017). Similarly, spelling accuracy was strongly related to the reading speed of the same words (Rossi et al., 2019).

Another line of work has shown that students' spelling skills can predict their future reading performance. For example, Clemens et al. (2014) found that kindergartners' spelling performance, which was evaluated using five different approaches, uniquely predicted reading skill that was composed of word reading and decoding, text reading fluency, and reading comprehension (as measured by Passage Comprehension) in Grade 1. Children's invented spelling (Ouellette & Sénéchal, 2017) and phonological spelling (spelling performance evaluated for the representation of phonological segments; Caravolas et al., 2001) in kindergarten were uniquely related to word reading skills in Grade 1. Furthermore, children's spelling performance in the summer following the completion of kindergarten predicted word reading performance in Grades 1, 2, 4, and 9 (Treiman et al., 2019).

Taken together, literature consistently indicates that children with word reading difficulty also experience spelling difficulty. Evidence also indicates that spelling provides precise information on the quality of lexical representations of words and predicts children's later reading performance, word reading in particular. Thus, it is reasonable to hypothesize that children's performance on spelling could be informative of children's reading difficulties over and above their performance on word reading. Furthermore, although several widely used screening assessment batteries include spelling, to our knowledge, few studies have examined the extent to which spelling performance is informative of reading difficulties over and above word reading skill.

Vocabulary and Reading

According to the Lexical Quality Hypothesis (Perfetti, 2007), vocabulary is important to word reading as vocabulary supports the forming and strengthening of connections between orthographic and phonological word forms. According to a line of work on "set for variability," children's attempt to correct mispronunciation in decoding is likely the mechanism for the relation of vocabulary to word reading (see Wegener et al., 2022, for a review). Studies have suggested the relation of vocabulary to word reading. For example, vocabulary was independently related to word reading over and above phonological awareness, letter writing automaticity, and alphabet knowledge fluency for kindergartners (Kim et al., 2014). In addition, 6-year-olds' vocabulary knowledge was related to their reading of regular words and irregular words (Ricketts et al., 2016). Studies have also shown that the relation of vocabulary knowledge to word reading is particularly important to reading irregular or exception words because knowledge of regular grapheme-phoneme correspondence is not sufficient for successfully reading them in English (Ricketts et al., 2007). For instance, receptive and expressive vocabulary explained the unique variance of irregular word reading for children in Grade 4 (Ouellette, 2006) and for children aged 8 to 10 years (Ricketts et al., 2007). Evidence also suggests that word-specific vocabulary knowledge, in addition to general vocabulary knowledge, accounts for the relation between vocabulary and word reading for children in Grades 3 and 4 (Kearns & Al Ghanem, 2019).

Vocabulary is also important to reading comprehension. While it is critical to screen for potential difficulties in word reading, it is also necessary to screen for potential difficulties in *comprehension*. After all, word reading without comprehension is not compatible with the goals of reading (Cain & Oakhill, 2007). Comprehension involves complex processes of decoding, parsing, constructing, and integrating information and draws on numerous language and cognitive skills (Kim, 2017, 2020b; Perfetti & Stafura, 2014). Therefore, insufficient oral language skills (e.g., vocabulary) and underdeveloped cognitive skills (e.g., inference-making) are risk factors for comprehension difficulty. In particular, the role of vocabulary in comprehension has been widely examined. A large body of studies has shown that vocabulary knowledge predicts comprehension (e.g., Braze et al., 2007; Ouellette, 2006; Sparapani et al., 2018), poor comprehenders have substantially weaker vocabulary knowledge than children with typical development or good comprehenders (e.g., Cain & Oakhill, 2006, 2007), and explicit and systematic instruction on vocabulary improves comprehension (Elleman et al., 2009; Stahl & Fairbanks, 1986).

The role of vocabulary in reading comprehension, however, is nuanced: Vocabulary is likely to exert its influence on reading comprehension *after* children reach a certain level of word reading proficiency (see the dynamic relations hypothesis in Kim, 2020b). This is because word reading skill places a large constraint on reading comprehension (Hoover & Gough, 1990; Kim, 2020b). In other words, the nature of reading comprehension changes over time—in the beginning phase of reading development, reading comprehension is largely constrained by word reading skill and associated precursor skills such as letter knowledge, whereas with the development of word reading skills, reading comprehension is increasingly a function of language and cognitive skills such as vocabulary, inference, and reasoning (Kim, 2020b; for evidence, see Adlof et al., 2006; Foorman et al., 2015; Hoover & Gough, 1990; Kim & Wagner, 2015; Lonigan et al., 2018). The role of oral language skills such as vocabulary in reading comprehension after children reach a certain proficiency in word reading is also found in the line of work with late-emerging poor readers. Late-emerging poor readers are those who do not exhibit signs of poor reading skills in early grades, but show poor reading skills in later grades (e.g., Grade 4 or later; Catts et al., 2012). Prior work suggests that approximately 13% to 19% of students are identified as late-emerging poor readers and more than half of them have

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problems in comprehension (Catts et al., 2012; Leach et al., 2003). Importantly, longitudinal studies showed that late-emerging poor readers have low oral language skills such as vocabulary, listening comprehension, and grammatical knowledge at an earlier time point (e.g., kindergarten; Badian, 1999; Catts et al., 2012; Compton et al., 2008). Given the key role of vocabulary in comprehension, perhaps it is not surprising that vocabulary is included in several prominent assessments in the US such as Lexia RAPID Assessment, MAP, and i-Ready Diagnostic.

Present Study

Despite the recognition that children with word reading difficulty also have difficulty with spelling and that spelling captures one's representation of lexical quality precisely (Frith, 1980; Perfetti, 2007), our understanding is limited about whether and how spelling, in addition to word reading, can indicate reading difficulties and improve identification of children at risk of reading difficulties. Moreover, information on students' vocabulary knowledge may aid early identification of students who may be at risk for word reading and comprehension difficulty. In the present study, we address these gaps in the literature with the following research question: Does information on students' spelling and vocabulary in kindergarten—over and above word reading performance—improve identification accuracy of children who are at risk of reading difficulties (word reading and reading comprehension) in kindergarten, Grade 1, and Grade 2?

The research questions were addressed using longitudinal data from kindergarten to Grade 2. We hypothesized that spelling skill would improve the precision of identifying students with word reading and reading comprehension difficulties across the primary grades. We did not have a clear hypothesis about whether vocabulary would improve the precision of identifying word reading difficulty over and above word reading and spelling, given relatively sparse literature. We posited that vocabulary would improve the precision of identifying reading comprehension difficulty at a later phase such as Grade 2.

The findings have an important potential implication: If spelling and vocabulary increase the precision of identifying students with reading difficulties, a reasonable recommendation is to include these as part of screening assessment batteries to improve identification accuracy and efforts in line with the MTSS framework (e.g., appropriate assessments and intensive instruction).

Method

Participants

The sample was composed of 247 kindergartners (55% boys; 56% Whites, 35% African-Americans, and 5% mixed-race children) enrolled in 32 classrooms across 8 schools who were followed to Grade 2. The mean age of participants in kindergarten was 5.32 years (SD = 0.44), the majority of the participants were eligible for free or reduced-price lunch (72%), and 1% were identified as English learners. The participating school district used *Wonders* (McGraw Hill) as the reading curriculum. The *Wonders* curriculum includes explicit instruction on word reading, spelling, precursors of reading (e.g., phonological awareness), and vocabulary. However, classroom observation data are not available to describe instructional practices precisely.

Measures

In kindergarten, children were administered a spelling task, a vocabulary task, two word reading tasks (Woodcock Johnson [WJ] Letter-Word Identification and the Sight Word Efficiency task of the Test of Word Reading Efficiency [TOWRE; Torgesen et al., 2012]), and a reading comprehension task (WJ Passage Comprehension). TOWRE and WJ Passage Comprehension were also administered in Grades 1 and 2. Items in all the tasks were scored dichotomously.

Spelling

Children's spelling skill was measured by an experimental dictation task in kindergarten. The task was composed of 13 items that included developmentally appropriate spelling patterns, such as high-frequency sight words (e.g., *the, you*), CVC words (e.g., *fan, bed*), high-frequency digraphs (e.g., *hang, ship*), and consonant clusters (e.g., *bump*). Cronbach's alpha was estimated to be .78. A complete list of the items in the spelling task can be found in Appendix.

Word Reading

Children's word reading skill was measured by two tasks: the WJ Letter-Word Identification task and the Sight Word Efficiency task of TOWRE. In the Letter-Word Identification task, the child was asked to read aloud letters and words of increasing difficulty. Cronbach's alpha was estimated to be .88. In the Sight Word Efficiency task, the child was asked to accurately read words of increasing difficulty within 45 s. The number of words read accurately was their score. Test–retest reliability for the Sight Word Efficiency task is reported to be .93 for 6- and 7-year-olds (Torgesen et al., 2012).

Vocabulary

The WJ Picture Vocabulary task (Woodcock et al., 2001) was used. In this task, the child was asked to identify pictured objects. Cronbach's alpha estimates were .69 in kindergarten, .73 in Grade 1, and .70 in Grade 2.

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Reading Comprehension

The WJ Passage Comprehension task (Woodcock et al., 2001) was used. In this task, the child was asked to read sentences and short passages and provide a missing word that makes sense within the context of the passage. Cronbach's alpha estimates were .75 in kindergarten, .88 in Grade 1, and .89 in Grade 2.

Procedures

Rigorously trained research assistants worked with children in a quiet place in the school. Reading tasks were administered individually whereas the spelling task was group administered (3–4 children). All the tasks were administered in the spring.

Data Analytic Strategies

The unique contributions of reading, spelling, and vocabulary to the overall screening efficiency of *a priori* base screening models were measured by a comparison of the area under the curve (AUC) between a base screening model (Model 1) and a value-added screening model (Model 2). The AUC is a summative probabilistic index, typically resulting from a receiver operating characteristic curve analysis, that quantifies the likelihood that a randomly selected person who has a condition (or diagnosis) measured by an outcome would be identified by a screener at a probability higher than a randomly selected person who does not have the condition or diagnosis. AUC ranges from .50 to 1.0 with values of .50 indicating that a screener has chance-level accuracy whereas perfect classification accuracy is marked by a value of 1.0.

Kindergarten word reading, spelling, and vocabulary predictors were the WJ Letter Word Identification, researcher-developed spelling, and WJ Picture vocabulary tasks, respectively. Word reading and reading comprehension outcomes from kindergarten to Grade 2 were measured by the TOWRE Sight Word Efficiency task and the WJ Passage Comprehension task, respectively. Three base screening models (Model 1) were calibrated for each outcome grade (i.e., K-2) and each outcome measure (i.e., word reading and reading comprehension): (1) a base screening model using only word reading as the predictor (i.e., Read model), (2) a base screening model using only spelling as a predictor (i.e., Spell model), and (3) a base screening model using both word reading and spelling as predictors (i.e., Read + Spell model). Two value-added screening models (Model 2) were used as comparisons to the base screening models: (1) the Read + Spell model was compared to the Read model and the Spell model, and (2) a value-added model of reading, spelling, and vocabulary (i.e., Read + Spell + VOC model) was compared to all three base screening models. The *pROC* package (Robin et al., 2011) in R software was used to estimate the AUC for all individual models. AUCs were then statistically compared using the bootstrapped approach that uses the AUC difference divided by the standard deviation of the bootstrap differences where the *p*-value provides evidence of the extent to which the null hypothesis of equivalent AUCs may be rejected.

Of particular importance to this study was how the criterion of word reading difficulties and reading comprehension difficulties would be operationally defined as this directly leads to how severity of risk is quantified. In the current sample, the 20th percentile of the sample performance rather than normative performance was used as the cutpoint for each of the kindergarten through Grade 2 outcome variables to maintain a consistent metric for outcome and grade. Base rates based on the normative 20th percentile by grade and outcome were as follows: kindergarten reading comprehension (24%), Grade 1 word reading (39%), Grade 1 reading comprehension (19%), Grade 2 word reading (33%), and Grade 2 reading comprehension (30%). Normative kindergarten word reading (TOWRE) information was not available.

Results

Preliminary Analysis

Missing data rates ranged from 0.00% to 31.82%. Little's test of data missing completely at random (MCAR) resulted in a failure to reject the null hypothesis that the data are MCAR, $\chi^2(74) = 84.70$, $p = .142$. Multiple imputation was used as an appropriate means of accounting for the missing data given the data met the MCAR assumption. Ten imputations were conducted using the *mice* package in R software, and results were aggregated for the purpose of analyses. Pre-imputation and post-imputation descriptive statistics and correlations for the full sample are reported in Table 1. Standard scores were used in the analysis with the exception of kindergarten spelling and TOWRE: Spelling was a researcher-developed measure (see above), and normative information for TOWRE is not available for kindergartners. Pre-imputation mean scores for the sample on the measures used for the screening inputs were 105.88 for kindergarten word reading (Letter-Word Identification; *SD* = 12.01), 4.64 for spelling (*SD* = 2.57), and 99.29 for vocabulary (*SD* = 9.47). The mean standard score for the sample on word reading and reading comprehension (Passage Comprehension) tended to be in the average range. Correlations among the measures ranged from .37 between WJ Passage Comprehension and spelling in kindergarten and Grade 2 to .82 between Grade 2 TOWRE Sight Word Efficiency and WJ Passage Comprehension. The descriptive statistics and correlations for post-imputation estimates were highly similar to the pre-imputation estimates. Rosner's test of

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TABLE 1
Means, Standard Deviations, and Correlations Using Pre- and Post-Imputation Data

Variable	*Pre-M*	*Pre-SD*	*Post-M*	*Post-SD*	1	2	3	4	5	6	7	8	9
1. K LWID SS	105.88	12.01	105.55	11.93	—	.58	.41	.63	.77	.75	.73	.80	.70
2. K Spelling raw	4.64	2.57	4.59	2.52	.58	—	.45	.68	.64	.56	.37	.58	.58
3. K Picture Vocab SS	99.29	9.47	99.27	9.44	.41	.44	—	.37	.42	.42	.42	.51	.47
4. K TOWRE raw	7.82	7.61	7.19	7.47	.63	.68	.38	—	.70	.50	.49	.51	.47
5. G1 TOWRE SS	91.94	14.90	91.29	14.75	.76	.63	.41	.68	—	.82	.63	.80	.79
6. G2 TOWRE SS	94.78	18.01	95.22	17.16	.74	.56	.42	.48	.80	—	.59	.80	.85
7. K PC SS	96.60	13.18	96.33	13.04	.73	.37	.40	.48	.61	.58	—	.66	.54
8. G1 PC SS	98.14	16.08	98.43	15.98	.78	.57	.46	.50	.79	.79	.64	—	.82
9. G2 PC SS	93.42	12.51	93.67	11.72	.69	.56	.45	.44	.77	.82	.53	.81	—

Note. All coefficients are statistically significant at .001 level. Values below the diagonal of the correlation matrix are pre-imputation estimates, and values above the diagonal of the correlation matrix are post-imputation estimates.
Abbreviations: G1, Grade 1; G2, Grade 2; K, Kindergarten; LWID, Letter Word Identification of Woodcock Johnson; PC, Passage Comprehension of Woodcock Johnson; Post, post-imputation; Pre, pre-imputation; raw, raw score; SS, Standard Score; TOWRE, Test of Word Reading Efficiency; Vocab, Vocabulary.

outliers via the *EnvStats* package (Millard, 2013) indicated that no statistical outliers were detected for the five most extreme values in kindergarten word reading (Letter Word Identification) and spelling, Grade 1 TOWRE Sight Word Efficiency, and Grade 2 TOWRE Sight Word Efficiency via the comparison of λ_i, R_i values. Two outliers were observed for kindergarten vocabulary as were four outliers for kindergarten TOWRE Sight Word Efficiency, one outlier for Grade 1 WJ Passage Comprehension, and two outliers for Grade 2 WJ Passage Comprehension. Except kindergarten TOWRE Sight Word Efficiency, for which floor effects were explanatory of the outliers, the remaining data points were not meaningfully separated from the distributions to warrant concern of inclusion in the data analyses.

Screening Efficiency Model Comparison

Word Reading Outcome

Results for the word reading outcome showed that the value-added model of Read + Spell improved overall screening efficiency when compared to the Read model in kindergarten ($D = -2.74$, $p = .006$) and Grade 1 ($D = -2.19$, $p = .028$), but not Grade 2 ($D = -1.32$, $p = .187$). Similarly, the Read + Spell model improved upon the base Spell model in kindergarten ($D = -2.03$, $p = .042$), Grade 1 ($D = -3.53$, $p < .001$), and Grade 2 ($D = -3.88$, $p < .001$), but the Reading + Spell + VOC model did not outperform the Read + Spell model in kindergarten ($D = 0.15$, $p > .500$), Grade 1 ($D = -0.35$, $p > .500$), or Grade 2 ($D = -0.50$, $p > .500$).

Reading Comprehension Outcome

The pattern of results for the reading comprehension outcome was identical across grade levels such that the value-added model of Read + Spell provided an improvement beyond the base Spell model (i.e., $D = -3.53$, $p < .001$ in kindergarten; $D = -4.27$, $p < .001$ in Grade 1; $D = -4.19$, $p < .001$ in Grade 2). As well, the Read + Spell + VOC model was a significant improvement beyond the base Spell model (i.e., $D = -4.51$, $p < .001$ in kindergarten; $D = -4.90$, $p < .001$ in Grade 1; $D = -3.94$, $p < .001$ in Grade 2); however, the Read + Spell + VOC model did not improve upon the Read + Spell model in any grade (i.e., $D = -1.02$, $p = .306$ in kindergarten; $D = -1.80$, $p = .071$ in Grade 1; $D = -0.09$, $p > .500$ in Grade 2). The Read + Spell + VOC model improved beyond the Read-only model in Grade 1 ($D = -2.04$, $p = .041$) but did not in kindergarten ($D = -0.76$, $p = .446$) or Grade 2 ($D = -1.08$, $p = .278$).

Discussion

Early identification of students at risk of reading difficulties is an essential part of effective reading instruction and

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prevention and mitigation of reading difficulties. In the present study, we investigated whether information on students' spelling and vocabulary in kindergarten—over and above word reading—increases the precision of identifying students with reading difficulties, using longitudinal data from kindergarten to Grade 2.

A striking finding in the present study is the role of spelling, over and above word reading, in improving classification/identification accuracy of word reading difficulties in kindergarten and Grade 1. As shown in Table 2, identification precision measured by AUC improved when spelling was included in addition to word reading. Studies have shown that although word reading and spelling are closely related skills, there are students who have spelling- and word reading-specific difficulties (Fayol et al., 2009; Furnes et al., 2019; Lee & Al Otaiba, 2017; Moll & Landerl, 2009; Torppa et al., 2017; Wimmer & Mayringer, 2002). As spelling requires greater precision and complete mental representation of words' phonological, orthographic, and morphological information, spelling reveals a great deal of accurate information on the skills necessary for reading development (Bourassa et al., 2006; Masterson & Apel, 2010; Ouellette et al., 2017; Rossi et al., 2019), more so than word reading assessments alone can. These results are in line with previous studies, which showed the relation of spelling skill to later word reading skill (Caravolas et al., 2001; Clemens et al., 2014; Ouellette & Sénéchal, 2017; Treiman et al., 2019), and extend them by revealing that spelling enhances identification accuracy of students' word reading difficulties over and above word reading performance.

Two aspects of the present findings with regard to the relation of spelling to reading difficulties are worth noting. First, spelling improved the precision of identifying children with word reading difficulty in kindergarten and Grade 1, but not in Grade 2. Reasons for this finding are not clear. One potential explanation is that as children develop their word reading and spelling skills, they may draw on sources of knowledge—phonological, orthographic, semantic knowledge—to a different extent for word reading. Specifically, in the very beginning phase of development such as in kindergarten and Grade 1, children may rely on phonological knowledge and foundational orthographic knowledge (e.g., letter sound) to a greater extent for their word reading, and spelling performance may tap these aspects as well. As children develop their word reading skill, they may increasingly draw on more sophisticated orthographic knowledge (e.g., orthographic patterns) and morphological knowledge for their word reading, and spelling may be limited in tapping these aspects. Future studies are needed to explore this speculation. The second aspect of the finding is that unlike for word reading difficulty, children's spelling skill did not make a unique contribution to enhancing precision of reading comprehension difficulty in primary grades once word reading was taken into consideration. These results indicate that the information provided by spelling for identifying children with reading comprehension difficulty largely overlaps with that provided by word reading at least for English-speaking children in primary grades.

Our hypothesis on vocabulary was not supported such that vocabulary in kindergarten did not uniquely increase precision of identifying children with word reading difficulty or reading comprehension difficulty beyond word reading and spelling. As noted above, vocabulary knowledge is hypothesized to support establishing the links between phonological and orthographic word forms (e.g., Perfetti, 2007), and evidence suggests relations of vocabulary knowledge to reading of regular and irregular words (Kim et al., 2014; Ricketts et al., 2016) and irregular words (Ouellette, 2006; Ricketts et al., 2007; Steacy et al., 2017). Growing evidence suggests that word- or item-specific knowledge of meanings might be particularly important for the vocabulary-word reading relation (Kearns & Al Ghanem, 2019; Wegener et al., 2018, 2020). Although previous studies showed that general semantic knowledge was also related to word reading (Kearns & Al Ghanem, 2019; Kim et al., 2014; Ricketts et al., 2016), general vocabulary knowledge as measured by a normed vocabulary task may be limited in tapping semantic support for word reading. This might explain the present findings and the absence of bidirectional relations between vocabulary and word reading (Georgiou et al., 2022).

Theory and evidence clearly indicate that vocabulary is an important predictor of reading comprehension (e.g., Cain et al., 2004; Kim, 2020b; Ouellette, 2006; Sparapani et al., 2018) and that children with reading comprehension difficulties have low vocabulary knowledge (see Cain & Oakhill, 2007, for a review). Therefore, we hypothesized that vocabulary would improve identification accuracy of students who have reading comprehension difficulty, especially beyond the very initial phase of reading development (e.g., Grade 2). However, vocabulary did not uniquely increase the precision of identifying children with reading comprehension difficulty over and above word reading and spelling. There are two potential explanations for the current findings. The first one is a developmental explanation noted in the literature review—in the beginning phase of reading development, word reading skill places a large constraint and limits the roles of language skills in reading comprehension (Adlof et al., 2006; Hoover & Gough, 1990; Kim, 2020b; Kim & Wagner, 2015), and therefore the role of vocabulary in reading comprehension would be largely captured at a later developmental phase (e.g., Grade 3 and later). For example, children's vocabulary in kindergarten predicted their reading comprehension in Grade 10 (Stanley et al., 2018). This speculation can be examined in a future study by using longer-term longitudinal data—whether vocabulary in kindergarten

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TABLE 2
Area under the Curve (AUC) Results by Model, Outcome, and Grade

Outcome grade	Outcome	Model 1	Model 2	AUC model 1	AUC model 2	D	*p*
Kindergarten	Word reading	Read	Read + Spell	0.822	0.870	−2.74	.006
		Read	Read + Spell + VOC	0.822	0.870	−2.45	.014
		Spell	Read + Spell	0.841	0.870	−2.03	.042
		Spell	Read + Spell + VOC	0.841	0.870	−1.84	.066
		Read +Spell	Read + Spell + VOC	0.870	0.870	0.15	.884
	Reading comprehension	Read	Read + Spell	0.827	0.835	−0.43	.662
		Read	Read + Spell + VOC	0.827	0.842	−0.76	.446
		Spell	Read + Spell	0.606	0.835	−4.47	<.001
		Spell	Read + Spell + VOC	0.606	0.842	−4.51	<.001
		Read +Spell	Read + Spell + VOC	0.835	0.842	−1.02	.306
Grade 1	Word reading	Read	Read + Spell	0.928	0.954	−2.19	.028
		Read	Read + Spell + VOC	0.928	0.958	−1.95	.051
		Spell	Read + Spell	0.848	0.954	−3.53	<.001
		Spell	Read + Spell + VOC	0.848	0.958	−3.64	<.001
		Read +Spell	Read + Spell + VOC	0.954	0.958	−0.35	.729
	Reading comprehension	Read	Read + Spell	0.919	0.927	−1.51	.132
		Read	Read + Spell + VOC	0.919	0.938	−2.04	.041
		Spell	Read + Spell	0.788	0.927	−4.27	<.001
		Spell	Read + Spell + VOC	0.788	0.938	−4.90	<.001
		Read +Spell	Read + Spell + VOC	0.927	0.938	−1.80	.071
Grade 2	Word reading	Read	Read + Spell	0.908	0.938	−1.32	.187
		Read	Read + Spell + VOC	0.908	0.939	−1.24	.214
		Spell	Read + Spell	0.831	0. 938	−3.88	<.001
		Spell	Read + Spell + VOC	0.831	0. 939	−3.98	<.001
		Read +Spell	Read + Spell + VOC	0. 938	0. 939	−0.50	.617
	Reading comprehension	Read	Read + Spell	0.922	0.936	−1.38	.167
		Read	Read + Spell + VOC	0.922	0.939	−1.08	.278
		Spell	Read + Spell	0.810	0.936	−4.19	<.001
		Spell	Read + Spell + VOC	0.810	0.938	−3.94	<.001
		Read +Spell	Read + Spell + VOC	0.936	0.939	−0.09	.930

Abbreviations: D, AUC test statistic; Model 1, Base screening model; Model 2, Value-added screening model. Word reading, Test of Word Reading Efficiency (TOWRE); Read, Woodcock-Johnson Letter-Word Identification; Reading comprehension, Woodcock-Johnson Passage Comprehension; VOC, Woodcock-Johnson Picture Vocabulary.

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predicts reading comprehension difficulty at later grades such as upper elementary grades and secondary grades.

The lack of vocabulary's predictive power for reading comprehension difficulty in primary grades in this study should not be taken to imply that there is no need for including vocabulary or language skills as part of assessment batteries for early identification purposes writ large. As noted above, reading comprehension is a multidimensional construct and what is tapped in reading comprehension tasks varies depending on the developmental phase of reading—it is substantially limited by word reading skill during the beginning phase of development whereas it is increasingly a function of language and higher order cognitive skills as word reading skills develop (Hoover & Gough, 1990; Kim, 2020b). Therefore, the early construct of reading comprehension that is substantially constrained by word reading is a product of developmental processes, and predictors of reading comprehension difficulty will differ depending on developmental phase (i.e., early versus later). Therefore, although vocabulary in kindergarten was not predictive of reading comprehension difficulty in kindergarten to Grade 2, vocabulary and language skills are likely to have predictive power for identifying children with reading comprehension difficulty at a later phase of reading development. This is suggested in longitudinal studies that showed the roles of vocabulary and language skills (e.g., listening comprehension) in later reading comprehension (e.g., Stanley et al., 2018; Verhoeven & van Leeuwe, 2012) and the literature on late-emerging poor readers reviewed above (e.g., Catts et al., 2012; Leach et al., 2003). Together, theory and evidence indicate the importance of including measures of language skills such as vocabulary and listening comprehension in early identification assessment batteries.

The second related potential reason for the lack of predictive power of vocabulary for reading comprehension difficulty is the measurement of reading comprehension. Reading comprehension tasks vary in the extent to which they tap into word reading and language and cognitive skills (Cutting & Scarborough, 2006; Keenan et al., 2008). Specifically, the WJ Passage Comprehension task used in the present study has been shown to tap into decoding skill to a greater extent than other component skills of reading comprehension (e.g., language comprehension; Keenan et al., 2008); Hence, the present findings may be a consequence of the reading comprehension measure at least to some degree. Reading comprehension is a complex and multidimensional construct (Catts, 2018) that is influenced by individuals' skills and knowledge, text features, and activity and task factors (Snow, 2002). Therefore, one's performance on reading comprehension tasks is influenced by these multiple factors (Collins et al., 2020; Eason et al., 2012; Kulesz et al., 2016), and relative contributions of language and cognitive skills vary depending on the nature of reading comprehension tasks and text features (Francis et al., 2018; Kim, 2020b). Measurement of reading comprehension has at least two implications. First, using multiple tasks and a latent variable approach improves the accurate measurement of reading comprehension. The other implication is the importance of awareness of the nature of reading comprehension tasks in the interpretation of results. Measurement using multiple instruments is not always feasible in practice due to time and resource constraints, and therefore, users need to be mindful of the nature of a reading comprehension task and its implications for the interpretation of results.

It should be noted that the generalizability of the findings is limited to English-speaking children in primary grades. Therefore, future studies are needed to replicate the present study with children in different developmental phases (e.g., upper elementary grades) and with those who learn to read in languages other than English. Furthermore, the results are based on specific reading tasks. Although both TOWRE and WJ Passage Comprehension measures are widely used in research and practice, the current results likely reflect this measurement characteristic, particularly for reading comprehension, and therefore, care needs to be taken for the measurement of reading comprehension. Future studies using multiple measures of reading comprehension will be useful.

Similarly, vocabulary knowledge in the present study measured only the breadth aspect, not other aspects/dimensions such as depth or fluency. Studies have examined different aspects of vocabulary knowledge with a variety of tasks, and magnitudes of their relations vary from moderate to strong (e.g., Binder et al., 2017; Ouellette, 2006; Tannenbaum et al., 2006). Whether different aspects of vocabulary knowledge have differential roles in identifying children with reading difficulties is an open question, which can be examined in future work.

Furthermore, the spelling task was a researcher-developed one. This was intentional to include a sufficient number of words that are developmentally appropriate for the target grade levels in the study—normed assessments tend to focus on finding normative information in spelling and include few items for children in the very initial phase of spelling development. Another limitation of the present study is no inclusion of another important reading skill, text reading fluency. A large body of literature clearly indicates text reading fluency as an important construct and skill that relates to word reading and reading comprehension (Fuchs et al., 2001; Kim et al., 2021; Kim & Wagner, 2015; Kuhn & Stahl, 2003; Wolf & Katzir-Cohen, 2001). Therefore, an interesting direction for future work is to include a measure of text reading fluency.

Practical Implications and Conclusion

The present findings overall indicate that it is possible to identify students' reading difficulties as early as kindergarten as

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children's manifestations in difficulties with word reading and spelling revealed their word reading difficulties in kindergarten and Grade 1. This is in line with prior work which showed that assessment at pre-kindergarten and kindergarten is a valid predictor of later literacy skills (e.g., Catts et al., 2016; Snowling & Melby-Lervåg, 2016). With early identification, the child does not have to wait to fail, and appropriate intervention can be provided to prevent later difficulties in reading (Bowyer-Crane et al., 2008; Snowling & Hulme, 2011), which is in line with the MTSS framework. The results suggest a need for and the utility of including spelling as an integral part of identification of children (i.e., screening) with reading difficulties as early as kindergarten (e.g., Caravolas et al., 2001; Clemens et al., 2014; Treiman et al., 2019). We recognize that adding measure to assessment batteries takes time and resources. However, an adapted version of a spelling assessment, although the spelling task in the present study was not an adapted one, would add minimal assessment time (e.g., 2 min). This seems to be a worthwhile investment of time for increased accuracy of identifying children with word reading difficulty and associated instructional efforts.

It is also worth noting that the cutpoint used in the present study was a *single* cutpoint based on implied joint probability across different skills/measures (word reading, spelling, and vocabulary; see Table 2). In other words, multiple cutpoints, that is, cutpoints for word reading, spelling, and vocabulary, respectively, were not used. Multiple cutpoints for multiple skills and measures can create inconsistencies and confusion in educational settings, and our findings of improved precision (see Table 2) are based on a single cutpoint taking into account information from multiple skills/tasks. Therefore, a similar approach can be employed in practice for making decisions in screening assessments instead of multiple cutpoints.

Accurate identification of children's needs is a prerequisite for supporting their successful literacy acquisition. The findings in the present study indicate a need for attending to spelling as an important source of information to identify students who are at risk for reading difficulties. Future work is needed to further shed light on and extend our understanding of effective assessment and identification practices, and intervention work.

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Conflict of Interest Statement

The authors declare no conflict of interest.

Data Availability Statement

Data will be available upon request.

NOTE

The work reported here was approved by Florida State University (HSC No. 2014.13495).

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APPENDIX

The Experimental Spelling Task in the Study

1. Is
2. The
3. You
4. Fan
5. Bed
6. Hop
7. Ship
8. Bump
9. Hang
10. Pool
11. Cute
12. Know
13. Girl

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