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# Invented Spelling, Word Stress, and Syllable Awareness in Relation to Reading Difficulties in Children

**Sheena Mehta**[1] · **Yi Ding**[2] · **Molly Ness**[3] · **Eric C. Chen**[4]

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**Abstract** The study assessed the clinical utility of an invented spelling tool and determined whether invented spelling with linguistic manipulation at segmental and supra-segmental levels can be used to better identify reading difficulties. We conducted linguistic manipulation by using real and nonreal words, incorporating word stress, alternating the order of consonants and vowels, and alternating the number of syllables. We recruited 60 third-grade students, of which half were typical readers and half were poor readers. The invented spelling task consistently differentiated those with reading difficulties from typical readers. It explained unique variance in conventional spelling, but not in word reading. Word stress explained unique variance in both word reading and conventional spelling, highlighting the importance of addressing phonological awareness at the supra-segmental level. Poor readers had poorer performance when spelling both real and nonreal words and demonstrated substantial difficulty in detecting word stress. Poor readers struggled with spelling words with double consonants at the beginning and ending of words, and performed worse on spelling two- and three-syllable words than typical readers. Practical implications for early identification and instruction are discussed.

**Keywords** Invented spelling · Word stress · Supra-segmental level · Reading difficulties

✉ Yi Ding
yding4@fordham.edu

1 University Counseling Center, University of Oklahoma, Norman, OK, USA

2 School Psychology Program, Division of Psychological and Educational Services, Graduate School of Education, Fordham University, 113 West 60th Street, Lowenstein Building Room 1008, New York, NY 10023, USA

3 Division of Curriculum and Teaching, Graduate School of Education, Fordham University, New York, NY, USA

4 Counseling Psychology Program, Division of Psychological and Educational Services, Graduate School of Education, Fordham University, New York, NY, USA

## Introduction

Invented spelling describes children's spontaneous or self-initiated efforts to represent words in print (Read 1971). Because invented spelling often emerges before children become established readers, Gentry and Gillet (1993) proposed that the early spelling attempts might promote reading development and integration of invented spelling might facilitate later reading acquisition. Ehri (1999) developed a four-stage model of word reading. The first stage is the pre-alphabetic stage, where individuals read words by retaining the visual aspects of words, or using the context to determine what it is. The partial-alphabetic stage is where individuals can identify some alphabetic letters and use them combined with the context to remember words by sight. By the full-alphabetic stage, the individual understands the graphophonemic system and can use their knowledge to perceive the relationship between phonemes and graphemes in words. The individual can read unfamiliar words and remember sight words. During the consolidated-alphabetic stage, the individual can consolidate their information of grapheme-phoneme blends into larger segments that can be found in different words.

Ehri's research on reading ability in children (e.g. Ehri 1975, 1998) and consequently on spelling (Ehri 1997) demonstrated a comparable developmental progression to Henderson (1985). Ehri's (1999) full alphabetic phase can be likened to Henderson's letter name stage, and Ehri's consolidated alphabetic stage can be likened to Henderson's within-word pattern. Spelling and reading both require a similar foundation of orthographic knowledge (e.g. Ehri 1997; Invernizzi 1992; Perfetti 1992; Richgels 1995). It was therefore considered that spelling can be considered an assessment approach of lexical representation and shed light on the perceptual features employed during word reading. Thereby, if the conventional orthography cannot be represented and held in an individual's memory, then the method in which the individual spells the same word will demonstrate characteristics of their orthographic knowledge that they are using to perceptually process the word when reading (Perfetti 1992). Essentially, reading and spelling can be considered related due to the shared function of phonological awareness (Ritchey 2008).

### Syllable Awareness at Segmental and Supra-Segmental Levels

One aspect of phonological awareness that has been measured to predict reading ability is syllable awareness, as it has been found to be important for reading acquisition (McBride-Chang and Kail 2002). Syllable awareness falls under the umbrella of phonological awareness (at the segmental level) and is a way to explore speech sounds. Typically learned in kindergarten as an auditory skill, syllable awareness develops in the beginning stages of phonological awareness. Caravolas and Landerl (2010) found that children's experience with syllable structure in their first language influences their phoneme awareness and alphabetic reading skills. Other aspects of phonological awareness such as tonal changes in Chinese or stressed syllables in English tap the supra-segmental level of phonological awareness (Ding et al. 2016), which is largely under-studied. Detecting syllable stress is considered a supra-segmental level of awareness because one cannot identify the stressed features of a syllable without the actual syllable itself (Most and Peled 2007). The ability to manipulate syllable stress and accurately represent a word in the stored lexical code has been associated with early reading and spelling (Wood 2006). Individuals with dyslexia have difficulties in detecting syllable stress (Leong et al. 2011). Incorporating syllable stress as a measure of reading difficulties is a unique feature of the current study.

## Invented Spelling and Its Relation to Reading and Spelling

With invented spelling, children attempt to spell words and may use unconventional spellings of words as they convert the sounds to print (Ouellette and Sénéchal 2008), such as spelling "jail" as "jl" (Henderson 1990). Over time, children progress from nonalphabetic representations to the representations of initial sounds, then to the beginning and ending sounds, and then to the integration of medial vowels in their invented spelling (Ferreiro 1991; Treiman 1993). Gentry and Gillet (1993) proposed that children's invented spelling initially relied on phonology to translate the sounds to print and then progressed to an incorporation of word-specific orthography. Through invented spelling, children represent words to print through their own experimentations and the process occurs naturally (Gentry and Gillet 1993).

When children first experiment with spelling, their attempts may be far from conventional spelling, but over time they develop in sophistication by increasing in phonological and orthographic accuracy to resemble the conventional spelling (Ehri and Wilce 1985).

Testing phoneme awareness and syllable awareness, the traditional tools (e.g., phoneme deletion or syllable deletion) to predict reading ability, is important but does not address the individual's understanding of the internal structure of a word, nor does it test if he or she understands the order of these sounds in a word, which invented spelling does. When compared to RAN and phonological awareness, invented spelling has received less widespread attention although research in this area spans the past 40 years. A handful of empirical studies examined invented spelling as an instructional approach to facilitate reading acquisition (Ouellette and Sénéchal 2008; Ouellette et al. 2013; Ouellette and Sénéchal 2017), but few have investigated its clinical utility to differentiate typical readers and struggling readers. Up to a decade ago Invernizzi and Hayes (2004) deemed the diagnostic capacity of spelling assessments as neglected. However, invented spelling has been shown to be a good predictor of reading ability (Bialystok et al. 2005). Invented spelling has shown great clinical utility in differentiating struggling readers from typical readers (e.g., Ouellette and Sénéchal 2008; Rack et al. 1992).

According to Stanovich (2000), invented spelling can enhance children's phoneme-grapheme correspondence, which is closely related to phonological awareness. Research demonstrates that spelling can predict reading in young children who are monolingual (e.g. Abbott et al. 2010; Foorman and Petscher 2010) and bilingual (Chua et al. 2014). Spelling was traditionally thought of as a process of rote memorization, but has been re-conceptualized as one of conceptual learning. McBride-Chang (1998) reported that performance for kindergarteners on an invented spelling activity was a stronger predictor of reading and spelling achievement than phonological awareness measures or verbal and nonverbal intelligence measures. McBride-Chang (1998) also found that invented spelling contributed unique variance to real and nonreal word decoding when phonological awareness was controlled for. Sénéchal et al. (2012) found that teaching invented spelling can contribute to reading skills in children with poor phoneme awareness. Ding et al. (2015) found that invented spelling outperformed syllable awareness and phoneme awareness assessment when identifying reading difficulties in Chinese readers.

Ouellette and Sénéchal (2008) do not consider invented spelling as children's efforts to recall or memorize conventional spelling. Instead, they deem it as a developmental process that reflects spelling attempts with increasingly accurate phonological and orthographic representation over time. Through a longitudinal study, Ouellette and Sénéchal (2017) found that invented spelling concurrently predicted reading, after controlling for phonological awareness and alphabetic knowledge. Along with alphabetic knowledge, invented spelling subsequently predicted reading and was a mediator between phonological awareness and early reading.

Along with phonological awareness, invented spelling subsequently predicted conventional spelling and mediated the effects of alphabetic knowledge. Ding et al. (2016) investigated invented spelling in English and Mandarin Chinese-speaking sixth graders who spoke English as a second language. Their invented spelling task in English used measures of syllable awareness, phoneme awareness, and word stress. The invented spelling task was found to be significant in accounting for variance in both Chinese and English reading and conventional spelling.

The current study thus sought to replicate Ding et al. (2016) in monolingual English-speaking children and explored the clinical utility of invented spelling as a diagnostic tool to differentiate struggling readers from typical readers. Rack et al. (1992) presented evidence that a good indicator of reading deficits in phonologically based decoding skills is the poor decoding skills for nonreal words. Thus, the current study included both real and nonreal words in the design of the invented spelling tool to avoid any memorization effects and measure true phonic knowledge. Similar to McBride-Chang (1995), we altered the difficulty level of the invented spelling items. The manipulations in McBride-Chang (1995) included the use of two kinds of consonants: fricatives and stops, identification of the number of consonants in a word, identification of the position of phonemes, and manipulation of consonants in differing positions. McBride-Chang's (1995) methodology provided ways to vary item difficulty on different phonological awareness tasks both within and across tasks without increasing task demands on memory. The present study incorporated similar linguistic manipulations to alter the difficulty levels of individual items by using real and nonreal words, incorporating word stress, alternating the order of consonants and vowels, and alternating the number of syllables.

## Word Stress

One aspect of phonology that has had received little attention is the stress of language. English is a stress-timed language, namely, it is made up of a pattern of stressed and non-stressed syllables (Holliman et al. 2010). In English, strong syllables often denote the beginning of lexical words, and alternating strong and weak syllables helps to distinguish words in speech to split a word into syllables and to help us correctly pronounce a word (Whalley and Hanson 2006). Syllables are a feature of the segmental aspect of language, and word stress is a feature of phonological awareness at the supra-segmental level (Most and Peled 2007). Word stress involves a level of language knowledge beyond the phoneme level that simply involves decoding skills (Zhang 2004). Wood et al. (2009) found that word stress skills play a role in the development of phonological awareness, reading and vocabulary. Jarmulowicz et al. (2007) found a correlation between stress production and decoding in third-grade children, and they suggested that word stress accuracy is a higher level of phonological awareness that develops after segmental aspects of phonological awareness. Evidence demonstrates that young children with reading difficulties do not have good knowledge of prosody, or the tempo, rhythm, and stress of language (Wood and Terrell 1998). Holliman et al. (2010) argued for speech rhythm sensitivity to be included in models of how children read. Schwanenflugel et al. (2004) explored prosody and decoding speed in children and found there to be a connection. De Bree et al. (2006) found that word stress acquisition in Dutch was delayed in 3-year-old children who were at risk of developing dyslexia, and they were less accurate on nonreal words.

Ding et al. (2015) incorporated lexical tone in pinyin invented spelling as a way to examine the supra-segmental level of phonological awareness. They found that Chinese children with poor reading skills struggled with lexical tone. Li and Suk-Han Ho (2011) found that Chinese children with dyslexia also demonstrated poor tone awareness skills. A parallel can be drawn between tone awareness in Chinese and word stress in English. Word stress is an inflectional feature of language and is an important but understudied component of the English language. Word stress is a feature of supra-segmental phonology, and supra-segmental cues have been found to be more difficult for individuals with reading difficulties to detect than for individuals without reading difficulties (Goswami et al. 2002; Talcott et al. 2003). Similar to Ding et al. (2015), the present study also incorporated this supra-segmental element of language (i.e., stressed syllable versus non-stressed syllable) into the proposed tool.

### Purpose of the Present Study

The study aimed to assess the clinical utility of an invented spelling tool as a diagnostic tool and to determine whether invented spelling with linguistic manipulation at segmental and supra-segmental levels can be used to better identify reading difficulties. This investigation explored the following research questions: (a) What is the pattern difference between individuals with reading difficulty and without reading difficulty on the invented spelling task? (b) What is the pattern difference between readers with reading difficulty and without reading difficulty on real words and nonreal words tasks? (c) Do children with reading difficulty show differentiated performance on invented spelling items with linguistic manipulation, including word stress, real and nonreal words, different combination of vowel and consonants, and different length of syllables? (d) In addition to RAN and phonological awareness, does invented spelling contribute any unique variance in word reading ability and conventional spelling?

## Methods

### Participants

Eighty-three principals of schools in metropolitan regions in two Northeastern U.S. states were contacted via email and 92 participants agreed to participate in the study. Out of the 92 participants who returned their consent forms, 32 were excluded from the study as they met at least one of these three exclusion criteria: documented intellectual disabilities by the school, documented mental health diagnoses, and being bilingual.

The final sample of 60 third graders were mostly female (67%) and had a mean age of 9.39 years (SD = .25). Participants were typically developing children without documented intellectual disabilities or severe mental health diagnoses. All children were native speakers of English and were not considered bilingual. The control group, defined as typical readers, consisted of 30 children who were considered by their teachers as not falling in the bottom 25% of their class for reading ability, according to school reading assessments. The experimental group consisted of 30 children, defined as having reading difficulties, who were considered by their teachers as falling in the bottom 25% of their class for reading ability. Teachers were given these specific definitions for both groups' reading ability in order to determine the appropriate group for each child.

### Measures

Dependent measures included word reading and conventional spelling. The independent measure included invented spelling of real and nonreal words. The measures that were controlled for were phonological awareness and RAN.

### *Word Reading Task*

This individually administered task used the Letter-Word Identification subtest of the *Woodcock-Johnson IV Tests of Achievement, Form A* (WJ IV ACH; Schrank et al. 2014). The Letter–Word Identification subtest measured reading encoding and required participants to name letters and read words aloud from a list. It was made up of 10 letter tasks and 68 vocabulary items. The subtest was discontinued after six consecutive incorrect items. The possible raw scores for this word reading task were 0-78, and these raw scores were converted to a standardized score. The median test reliability for this subtest was 0.94.

### *Conventional Spelling Task*

This group-administered task used principles of the Spelling subtest in the *Wide Range Achievement Test-Revision 4* (WRAT-4; Wilkinson and Robertson 2006). The Spelling subtest measured the participant's capacity to encode sounds and write them through dictation. It was made up of 13 letter tasks, with two additional points available for correctly spelling their name and 42 vocabulary items. The 42 vocabulary items were from elementary English reading books and were presented in grade-level order. Participants were required to spell each word after the examiner on the audiotape orally read the word. All items were administered to ensure the ceiling was identified for all in the group. Students were told at the beginning of the task that they were not expected to know all of the words, but to try their best. The scoring remained as stated in the manual, and no credit was given after the discontinue criterion of 10 incorrect scores on consecutive items. The internal consistency reliability coefficient for this task was 0.87–0.93. The possible raw scores for this conventional spelling task were 0–57, and these raw scores were converted to a standardized score.

### *Phonological Awareness Task*

The individually administered subtest, Elision, of the *Comprehensive Test of Phonological Processing* (CTOPP; Wagner et al. 1999) was a comprehensive measure of phonological ability. Elision consisted of 20 items that measured the extent to which an individual could say a word and say what is left after being asked to drop one of the designated sounds. For example, say "blend" without saying /l/ or say "bold" without saying /b/. The sound to be deleted could be initial, middle, or ending sounds. All participants began with the three practice items. If all practice items were answered incorrectly, the subtest was discontinued. If one or more of the practice items were answered correctly, item 1 onwards was administered. The ceiling was reached when the participant answered three consecutive items incorrectly. The possible raw scores for this phonological awareness task were 0–20, and these raw scores were converted to standardized scores. The internal consistency reliability of the Elision subtest was 0.86–0.91 for ages 8–12.

### *RAN Letter Task*

The individually administered Letter subtest of the RAN test consisted of an array of five lower case letters (o, a, s, p, d) that were repeated 10 times on a chart. Children were required to name these letters as fast as they could, and the time taken (in seconds) to complete the chart was recorded (Denckla and Rudel 1974). Test–retest reliability for 5–10 years was reported to be .87 (Wolf and Denckla 2005). The Letter subtest was chosen as it is most relevant to reading and spelling (Neuhaus et al. 2001).

*Invented Spelling Task*

This group-administered task consisted of 14 real and 14 nonreal words that were adapted from Ding et al. (2016). Sample items were provided in Table 1. The 14 real words were made up of eight single-syllable words, four two-syllable words, and two three-syllable words. Four of the single-syllable words followed a consonant–vowel–consonant (CVC) pattern, two followed a consonant–consonant–vowel–consonant (CCVC) pattern, and two followed a consonant–vowel–consonant–consonant (CVCC) pattern. Two of the two-syllable words were stressed in the first syllable and the other two words were stressed in the second syllable. All three-syllable words were stressed in the third syllable. The nonreal words were designed similarly. Table 1 displays the structure of the invented spelling task. Participants were told that some words were real and some were nonreal and were given four practice items written on the whiteboard. Two of these were real words and two were nonreal words. After the examiner on the audiotape read aloud each item twice, participants were required to spell and write out the word they heard. Participants were then told on the audiotape that the items would be replayed and they should circle the stressed syllable. They were given four practice items before items 9–14 and 23–28 were replayed.

Based on Ouellette and Sénéchal's (2008) coding design, each spelling was scored on a 7-point scale from 0–6. We included the details of the scoring scheme in "Appendix A". The coding scheme addressed the number of phonemes represented and gave credit for the level of orthographic representations. The total number of points possible for invented spelling was 0–168, of which 0–84 points were possible for invented spelling of real words and 0–84 points were possible for invented spelling of nonreal words. Another rater independently rated one third of the data, and the inter-rater reliability was 0.94.

One point was given when the correct syllable was identified as being stressed in items 9–14 (real words) and items 23–28 (nonreal words). A point was awarded if the participant only circled a portion of a syllable that was stressed, as awareness of stressed syllables was being examined. The total number of points for correctly identified syllable stress was 0–12, and this raw score was converted into a percentage.

## Procedure

Participants were tested during class time on the measures described above. The first author served as the examiner. For the sake of time management and minimal disruption to instruction time, the invented spelling task and conventional spelling task were administered to participants as a group. Participants completed these tasks first. The phonological awareness task, RAN task, and word reading task were administered on an individual basis. Instructions and items for the invented spelling tool, conventional spelling task, and phonological awareness task were pre-recorded using an American English native speaker to standardize administration across the sample. Parents were asked to provide consent and to complete demographic questions for their child. Participants were asked for assent. We scored the raw scores for the phonological awareness task, word reading task, and conventional spelling task and then converted them to standard scores as described in the manuals.

Demographic data were collected and analyzed for the 60 participants. All analyses were calculated using IBM SPSS Statistical Data Editor version 20. Descriptive statistics were calculated for the following variables: RAN, phonological awareness, word reading, conventional spelling, invented spelling, and word stress, as displayed in Table 2.

**Table 1** Invented spelling task item structure

| Structure | Section | *n* | Example | Answer |
|---|---|---|---|---|
| Real words, CVC, stop consonant-end | Items 1–2 | 2 | mæp | Map |
| Real words, CVC, labial consonant-end | Items 3–4 | 2 | well | Well |
| Real words, CCVC, stop consonant-end | Items 5–6 | 2 | flæg | Flag |
| Real words, CVCC, fricative consonant-start | Items 7–8 | 2 | fa:st | Fast |
| Real words, 2 syllables, 1st stressed | Items 9–10 | 2 | ‘bʌtə | Butter |
| Real words, 2 syllables, 2nd stressed | Items 11–12 | 2 | ə’jʌst | Adjust |
| Real words, 3 syllables, 3rd stressed | Items 13–14 | 2 | kægə’ru: | Kangaroo |
| Nonreal words, CVC, stop consonant-end | Items 15–16 | 2 | meb | Meb |
| Nonreal words, CVC, labial consonant-end | Items 17–18 | 2 | vel | Vell |
| Nonreal words CCVC, stop consonant-end | Items 19–20 | 2 | plig | Plig |
| Nonreal words CVCC, fricative consonant-start | Items 21–22 | 2 | fept | Fept |
| Nonreal words, 2 syllables, 1st stressed | Items 23–24 | 2 | ‘bintə | Binter |
| Nonreal words, 2 syllables, 2nd stressed | Items 25–26 | 2 | ə’mist | Amist |
| Nonreal words, 3 syllables, 3rd stressed | Items 27–28 | 2 | inmi’ta:p | Inmitarp |

*CVC* consonant–vowel–consonant, *CCVC* consonant–consonant–vowel–consonant, *CVCC* consonant–vowel–consonant–consonant

**Table 2** Descriptive statistics of all measures

| Measures | *M* | SD | Skewness | Kurtosis |
|---|---|---|---|---|
| Age[a] | 9.39 | 0.25 | − 0.48 | − 0.05 |
| RAN[b] | 26.43 | 5.11 | − 0.04 | − 1.19 |
| Phonological awareness[c] | 9.05 | 3.12 | 0.57 | − 1.39 |
| Word reading[d] | 110.82 | 20.44 | − 0.14 | − 1.23 |
| Conventional spelling[e] | 113.78 | 18.57 | 0.15 | − 1.40 |
| Invented spelling[f] | 148.95 | 10.17 | − 0.33 | − 0.83 |
| Word stress[g] | 47.75 | 23.33 | 0.17 | − 1.52 |

[a]Range 8.67–9.92 years
[b]Range 16.48–36.21 s
[c]Range 5–15 standard score
[d]Range 75–143 standard score
[e]Range 84–145 standard score
[f]Range 128–167 points
[g]Range 17–83%

## Results

### Overall Performance on Invented Spelling Task

Independent samples *t* tests were computed to determine if there were differences between the control group and the group with reading difficulties on word reading, conventional spelling, phonological awareness, RAN, and invented spelling (see Table 3). Because we conducted multiple analyses on the variables that might be highly correlated, it increased the likelihood of observing a significant result by pure chance. Thus, we used Bonferroni correction ($\alpha_{\text{altered}} = 0.05/8 = 0.006$, $p$ values were compared to $\alpha_{\text{altered}}$) for analyses in Table 3. Regarding the first research question, the results suggested that poor readers performed worse on the invented spelling task than typical readers [$t(58) = 4.93$, $p < .001$].

## Performance on Real Words Versus Nonreal Words

The second research question was to determine if there were differences in invented spelling scores of real and nonreal words between the control group and the group with reading difficulties (see Table 3). The control group outperformed the group with reading difficulties on the invented spelling scores of real words ($t = 6.71$, $p < .001$) and nonreal words ($t = 3.32$, $p < .01$).

## Performance on Invented Spelling Items with Linguistic Manipulation

The recorded scores reflected the participants' percentage of accuracy on target items. There was a statistically significant difference between the correctly identified stressed sounds by the control group and the group with reading difficulties ($t = 18.67$, $p < .001$). In other words, the group with reading difficulties could only correctly identify less than 1/3 of the word stress, whereas the control group correctly identified more than 2/3 of the word stress.

Phonological manipulations within the invented spelling task were further analyzed. As aforementioned, when the task was designed, real word items 1–4 were constructed in parallel to nonreal word items 15–18 with the consonant–vowel–consonant (CVC) structure. Real word items 5–8 were constructed similarly to nonreal items 19–22 with the CCVC or CVCC structure. As these parallels each had the same number of maximum points, a comparison of the raw points was possible. In the overall sample, the mean score for invented spelling of CVC words was significantly higher than the mean score for invented spelling of CCVC/CVCC words ($t = 2.76$, $p = .008$). There was no statistically significant difference in invented spelling accuracy on CVC words between two groups. The control group outperformed the group with reading difficulties on CVCC/CCVC words ($t = 2.15$, $p = .036$) (Table 4).

When the invented spelling task was designed, real word items 1–8 and nonreal word items 15–22 both consisted of one syllable. Real word items 9–12 were constructed similarly to nonreal words items 23–26, both consisting of two syllables. Real word items 13–14 were constructed in parallel with nonreal word items 27–28, both consisting of three syllables. Accuracy in spelling one-, two-, and three-syllable words was compared using the percentage of spelling accuracy in each area. As shown in Table 5, the control group had a significantly higher invented spelling mean for one- ($t = 2.32$, $p = .024$), two- ($t = 3.75$, $p < .001$), and three- ($t = 4.13$, $p < .001$) syllable words than the group with reading difficulties.

Paired-samples $t$ tests were conducted to compare invented spelling accuracy between one-, two-, and three-syllable words within the overall sample (see Table 5). There was a significant difference in the invented spelling accuracy for one-syllable words ($M = 92.22$, $SD = 6.87$) and two-syllable words ($M = 87.25$, $SD = 9.25$; $t = 4.545$, $p = .000$) within the overall sample. There was also a significant difference in the invented spelling accuracy for two-syllable words and three-syllable words ($M = 74.63$, $SD = 13.32$; $t = 9.575$, $p = .000$). In addition, there was a significant difference in the invented spelling accuracy for one-syllable words and three-syllable words ($t = 11.668$, $p = .000$) within the overall sample. The participants performed the best on one-syllable words and the worst on three-syllable words. A paired-samples $t$ test was also computed to compare invented spelling accuracy in one-, two-, and three-syllable words within each group. Within each group, the mean score on three-syllable words was lower than the mean score on one- and two-syllable words, with one-syllable words having the highest mean score for invented spelling in both groups.

**Table 3** Independent samples *t* test of all measures

| | Word reading | | Conventional spelling | | Phonological awareness | | RAN | | Invented spelling | | Real words | | Nonreal words | | Word stress | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *M* | SD | *M* | SD | *M* | SD | *M* | SD | *M* | SD | *M* | SD | *M* | SD | *M* | SD |
| TR | 128.07 | 9.27 | 130.80 | 8.13 | 11.07 | 3.02 | 21.91 | 2.43 | 154.43 | 7.21 | 82.50 | 1.31 | 71.93 | 7.28 | 69.17 | 10.65 |
| PR | 93.57 | 12.20 | 96.77 | 6.01 | 7.03 | 1.52 | 30.95 | 2.23 | 143.47 | 9.82 | 77.93 | 3.49 | 65.53 | 7.65 | 26.33 | 6.67 |
| T | 12.34 | | 18.43 | | 6.54 | | −15.00 | | 4.93 | | 6.71 | | 3.32 | | 18.67 | |
| *p* | < .001*** | | < .001*** | | < .001*** | | < .001*** | | < .001*** | | < .001*** | | < .001*** | | < .001*** | |
| Effect size | .85 | | .92 | | .65 | | −.89 | | .54 | | .66 | | .39 | | .92 | |

Bonferroni correction $\alpha_{altered} = 0.05/8 = 0.006$, *p* values were compared to $\alpha_{altered}$
*TR* typical readers, *PR* poor readers
$*p < 0.05$; $**p < 0.01$; $***p < 0.001$

**Table 4** Independent samples *t* tests of CVC and CVCC/CCVC invented spelling scores in overall sample, typical readers, and poor readers; and paired-samples *t* test of CVC and CVCC/CCVC invented spelling in overall sample

| Group | CVC words: items 1–4, 15–18 | | CVCC/ CCVC words: items 5–8, 19–22 | | Paired-sample *t* test |
|---|---|---|---|---|---|
| | *M* | SD | *M* | SD | |
| TR | 45.73 | 3.37 | 44.57 | 3.49 | |
| PR | 44.27 | 3.71 | 42.23 | 4.83 | |
| Total | 45.00 | 3.59 | 43.40 | 4.34 | CVCC/CCVC < CVC |
| *t* | 1.60 | | 2.15 | | 2.76 |
| *p* | *ns* | | .036* | | 0.008** |
| Effect size | .20 | | .27 | | |

Total = Overall sample
*TR* typical readers, *PR* poor readers, *CVC* consonant–vowel–consonant, *CCVC* consonant–consonant–vowel–consonant, *CVCC* consonant–vowel–consonant–consonant
$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

## Invented Spelling and Word Stress in Relation to Word Reading and Conventional Spelling

Correlation coefficients between each variable for the overall sample (see Table 6) were computed to determine the relationship between each variable in terms of statistical significance. The following correlations were found to be statistically significant. Word reading was positively correlated with conventional spelling, phonological awareness, and invented spelling. Word reading was negatively correlated with RAN. This suggests that higher accuracy in conventional spelling, higher accuracy in invented spelling, and higher levels of phonological awareness were associated with higher levels of word reading. Conventional spelling was positively correlated with phonological awareness and invented spelling. Conventional spelling was negatively correlated with RAN. This indicates that higher accuracy in conventional spelling was associated with higher levels of phonological awareness and higher accuracy in invented spelling. Higher accuracy in conventional spelling was also associated with faster RAN times. Phonological awareness had a positive correlation with invented spelling and a negative correlation with RAN, suggesting that higher levels of phonological awareness were connected with higher accuracy in invented spelling and faster RAN times. RAN was also negatively correlated with invented spelling, indicating that faster RAN times were associated with higher accuracy in invented spelling. The correlations between words stress and word reading (r = .80**), conventional spelling (r = .88*), and RAN (r = − .84**) were much higher than it was with phonological awareness (r = .56**). It indicates that children might utilize their reading and spelling skills when they needed to determine word stress.

A hierarchical regression analysis was performed in which word reading was regressed on invented spelling and word stress while controlling for RAN and phonological awareness. The first two variables entered in the regression as a block in step one were phonological awareness and RAN (see Table 7). The finding indicates that phonological awareness ($\beta$ = .464, $p < .001$) and RAN ($\beta$ = .464, $p < .001$) accounted for 69.7% of the variance in word reading. The invented spelling score was entered into the second block. Addition of

**Table 5** Independent samples $t$ tests and paired-sample $t$ test of invented spelling accuracy on one, two, and three syllable words in overall sample, typical readers, and poor readers

| Group | A: items 1–8, 15–22 | | B: items 9–12, 23–26 | | C: items 13–14, 27–28 | | Paired-sample $t$ test |
|---|---|---|---|---|---|---|---|
| | *M* | SD | *M* | SD | *M* | SD | |
| TR | 94.20 | 5.90 | 91.30 | 7.05 | 80.93 | 9.09 | B < A ($p = .045$), C < B ($p = .000$), C < A ($p = .000$) |
| PR | 90.23 | 7.29 | 83.20 | 9.51 | 68.33 | 14.01 | B < A ($p = .000$), C < B ($p = .000$), C < A ($p = .000$) |
| Total | 92.22 | 6.87 | 87.25 | 9.25 | 74.63 | 13.32 | B < A ($p = .000$), C < B ($p = .000$), C < A ($p = .000$) |
| $t$ | 2.32 | | 3.75 | | 4.13 | | |
| $p$ | .024* | | .000*** | | .000*** | | |
| Effect size | .29 | | .44 | | .47 | | |

A = One-syllable words (items 1–8, 15–22), B = Two-syllable words (items 9–12, 23–26), C = Three-syllable words (items 13–14, 27–28), Total = Overall sample
*TR* typical readers, *PR* poor readers
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

**Table 6** Correlation matrix of all measures for the overall sample

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. Word reading | | | | | |
| 2. Conventional spelling | .89** | | | | |
| 3. Phonological awareness | .73** | .72** | | | |
| 4. RAN | − .74** | − .85** | − .54** | | |
| 5. Invented spelling | .47** | .61** | .44** | − .47** | |
| 6. Word stress | .80** | .88** | .56** | − .84** | .53** |

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

invented spelling did not lead to a statistically significant increase in $R^2$ [$\Delta R^2 = .001$; $F(1, 56) = .259$, $p = .613$]. Word stress was entered into the third block of the regression model. Addition of word stress explained unique variance in word reading [$\Delta R^2 = .058$; $F(1, 55) = 12.981$, $p = .001$].

Another hierarchical regression analysis was performed in which the conventional spelling was regressed on invented spelling and word stress while controlling for RAN and phonological awareness (see Table 7). Phonological awareness and RAN were entered into the first step. This regression was statistically significant [$F(2, 57) = 122.906$, $p < .001$] and resulted in a statistically significant increase in conventional spelling ($R^2 = .812$). Invented spelling was entered into the second block of the hierarchical regression. Addition of invented spelling led to a statistically significant increase in $R^2$ [$\Delta R^2 = .030$; $F(1, 56) = 10.495$, $p < .01$], which indicates that invented spelling explained unique variance in conventional spelling when controlling for RAN and phonological awareness. Word stress was entered into the third block of the hierarchical regression. Addition of word stress explained unique variance in conventional spelling [$\Delta R^2 = .040$; $F(1, 55) = 18.775$, $p < .001$].

## Discussion

### Differentiated Performance in Typical Readers and Struggling Readers

The results indicated that poor readers struggle with invented spelling, which is consistent with previous research (e.g., Ding et al. 2015; Ouellette and Sénéchal 2008; Rack et al. 1992). The exploratory nature of invented spelling provides children with the opportunities to make sense of the correspondences between phoneme (sounds) and grapheme (print). In turns, invented spelling requires the skills to make connections between phonological and orthographic representation (Ouellette and Sénéchal 2008). The ability to develop the correspondences between phoneme and grapheme appears to be integrated in many reading acquisition theories, such as self-teaching theory (Share 1995), phase theory (Ehri 2005), and lexical quality theory (Perfetti and Hart 2002). Thus, it is anticipated that invented spelling might be a precursor to facilitate children's learning to become a reader. In empirical studies, sophistication of children's invented spelling in kindergarteners predicted reading performance in elementary school (McBride-Chang 1998; Shatil et al. 2000), supporting our findings that poor readers performed worse than typical readers on invented spelling tasks.

Invented spelling that involves real words only might lead to performance that is influenced by practice or memory effects. In other words, children might perform better on invented

**Table 7** Hierarchical regression for invented spelling in relation to word reading and conventional spelling

| Variables | Model 1 | | | Model 2 | | | Model 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | βeta | $R^2$ | $R^2$change | βeta | $R^2$ | $R^2$change | βeta | $R^2$ | $R^2$change |
| DV: word reading | | | | | | | | | |
| PA | .464 | | | .453 | | | .401 | | |
| RAN | − .487 | .697 | .697*** | − .472 | | | − .134 | | |
| Invented spelling | | | | .044 | .698 | .001 | − .021 | | |
| Stress | | | | | | | .471 | .756 | .058** |
| DV: conventional spelling | | | | | | | | | |
| PA | .365 | | | .313 | | | .269 | | |
| RAN | − .650 | .812 | .812*** | − .582 | | | − .299 | | |
| Invented spelling | | | | .202 | .841 | .030** | .147 | | |
| Stress | | | | | | | .394 | .882 | .040*** |

*DV* dependent variable, *PA* phonological awareness, *RAN* rapid automatized naming
$^*p < .05$; $^{**}p < .01$; $^{***}p < .001$

spelling words which they are frequently exposed to. Thus, the present study tapped into the examination of invented spelling with both real and nonreal words. Scarborough (2009) reported that children with reading difficulties struggle to apply their phonological skills to decode unfamiliar words. In our study, poor readers performed worse on both real words and nonreal words. It indicates that poor phoneme-grapheme correspondence also hinders children's ability to spell out nonreal words (unfamiliar words), although the nonreal words we designed were phonetically regular (e.g., binter, plig). According to Henderson's (1985) five developmental stages of spelling stage theory, the third stage (the within-word pattern stage) is where the child learns spelling from exposure to reading and where sight word knowledge aids spelling unfamiliar words. The present study supports the connection between invented spelling ability and reading ability. A task of spelling nonreal words can give a valid indication of how a child understands phoneme-grapheme correspondence and how a child can use the letters together to form words. Spelling a real word only cannot help to determine whether a child is recognizing the word by sight. Thus, future researchers should consider the use of nonreal words in invented spelling tasks to eliminate the effects of memorization of sight words.

Many assessment tools of phonological awareness such as syllable deletion or phoneme deletion are at the segmental level of phonology, whereas the phonological awareness at the supra-segmental level such as word stress has received very little attention. Our invented spelling task embedded the design of stressed syllables. The findings indicated that children with reading difficulties struggled more than typical readers in detecting stressed syllables in words, which suggests the difficulty at the supra-segmental level. Word stress is considered as a suprasegmental property of rhythmic group which reflects important relations between weak and strong syllables within a word (Beyermann and Penke 2014). There are different systems of word stress in alphabetic languages. Some languages can be categorized as fixed-accent languages in which the main stress position is fixed on a particular syllable. Some languages such as English or German can be categorized as variable-accent languages in which the main stress syllable is not fixed on the same syllable in a word. English is a language with variable accent positions and it does not have an explicit orthographic signal system for stress positions. In other words, stressed syllable in an English word does not have an explicit mark on a printed syllable. It is not surprising that some English language teachers (e.g., English language teachers in China) who teach English-as-a-foreign-language learners in other countries have to visually highlight stressed syllable within a printed word in order to explicitly teach the position of word stress (e.g., temperature is presented as TEMperature or winter is coupled with phonetic cues such as /'wintə/). In native speakers of English, explicit teaching of word stress is rarely seen and children often master word stress through natural exposure to daily speech and learn word stress implicitly. There have been empirical studies examining the influence of word stress on word recognition. For example, Colombo (1991) found that Italian-speaking participants had fewer errors on regularly stressed words than on words with irregular stress pattern in a lexical-decision task. Similarly, Arciuli and Cupples (2006) reported the effect of regularity of word stress in English-speaking participants in a lexical-decision task and the results showed that typically stressed words elicited fewer errors than atypically stressed words. The current study found that individuals with reading difficulties correctly identified only 1/3 of the word stress, whereas typical readers successfully identified 2/3 of the word stress. It indicated that struggling readers do not naturally master word stress when word stress is not explicitly taught. The findings confirm previous research suggesting that the ability to detect syllable and word stress is associated with reading ability (Anthony and Francis 2005; Holliman et al. 2010) and spelling (Wood 2006). Similarly, Leong et al. (2011) found that individuals with dyslexia had difficulties in detecting syllable stress. In the present study, word stress explained unique variance in both word reading and conventional spelling, indicating the importance of addressing the supra-segmental level of phonological awareness in future assessment instruments.

It is interesting that the correlations between words stress and word reading, conventional spelling, and RAN were much higher than it was with phonological awareness. Based on the orthographic depth theory by Frost et al. (1987), reading in languages with relatively opaque grapheme-phoneme correspondences (e.g., English) relies more on the direct route to lexicon. On the other hand, reading in languages with relatively transparent grapheme-phoneme correspondence (e.g., Spanish, German) relies more on the indirect phonological route.

## Practical Implications

The invented spelling was not found in the current study to have a unique contribution to word reading; therefore, the result does not replicate the results of McBride-Chang (1998) and Ding et al. (2016). However, there was a significant difference in performance between typical readers and poor readers on the invented spelling task. The results of this study have implications for teachers to highlight the importance of analyzing invented spelling samples of their students, as explained by Ness (2010). As expected, measures of segmental levels of phonological awareness connected to word reading ability. The invented spelling task used in the current study incorporated aspects of the individual's phonological awareness at the segmental level and the supra-segmental level. Points were awarded for the correct initial grapheme and if the phonemes were represented with phonetically related or conventional letters. This approximation of degree of spelling accuracy enables educators to determine the individual's level of phonic skills and his or her understanding of alphabetic orthography, thus making this invented spelling tool much more informative during assessment than a traditional spelling test.

There can be any level of spelling stages within one classroom (Ness 2010). This tool can be used to group students within the classroom who are at similar stages of spelling, so that teachers can more accurately plan their instruction around what phonics or aspects of spelling need to be taught to enable them to progress to the next level of instruction. Small group instruction for reading is a common intervention, but this tool may pave the way to identify how to form groups for differentiated spelling instruction. Knowing specifically which areas a child struggles with allows teachers not only to provide explicit instruction to address the weakness, but also to provide opportunities in the classroom for the child to apply the skills and strategies they learn. Ding et al. (2015) found that pinyin invented spelling was more effective in distinguishing between poor, average, and good readers than the traditional Chinese phonological awareness task. The present study demonstrated how invented spelling can differentiate between typical and poor readers.

The present study found that invented spelling did contribute unique variance to conventional spelling. The invented spelling task incorporated a conventional spelling task in the sense that it required the participants to spell real words, but it also went beyond this by requiring the participants to spell nonreal words. The current study demonstrated that poor readers struggled with spelling real words more than typical readers. Poor readers also struggled with spelling nonreal words more than typical readers. Therefore, spelling nonreal words can be used to differentiate between typical and poor readers. Poor readers have been shown to have poor phonological awareness, which consequently can affect their ability to spell unfamiliar words. Poor readers are less likely to be able to use phonetically related or conventional letters to represent the phonemes in a word. Using nonreal words in a spelling task is a true form of assessing phonological awareness at the segmental level as it is not something that could have been previously memorized. The current study highlights the importance of using nonreal words in diagnostic and screening tools.

In order to perform the invented spelling task, children need to have phoneme segmentation skill and phoneme-grapheme correspondence skills. Pronounced difficulties with the invented spelling task indicated that phoneme-grapheme correspondences skills are not internally formed. Invented spelling could be used as an instructional intervention approach to facilitate early reading. Ouellette and colleagues conducted a series of interventions based on invented spelling and reported that invented spelling with instructional feedback benefits an analytical approach and enhances the integration of phonological and orthographic knowledge, which facilitates reading acquisition (Ouellette and Sénéchal 2008, 2017).

The task also required participants to identify the stressed syllable, which assesses the supra-segmental level of phonological awareness. The current results indicated that children with reading difficulties were found to have substantial difficulty detecting word stress. Word stress and its contribution to reading is an area of literacy that has received little research to date compared to other metalinguistic skills of reading. Traditional reading difficulty screening tools incorporate the aforementioned segmental level measures, such as measures at the syllable or phoneme level; however, few incorporate supra-segmental level measures like the current invented spelling tool. The current results add to the previous literature that supra-segmental cues may be more difficult for poor readers to identify (Goswami et al. 2002; Talcott et al. 2003). Poor recognition of word stress can affect phonological representation. Wood et al. (2009) also found that word stress is connected with phonological awareness development and impacts reading and vocabulary. Similar to the current study, Jarmulowicz et al. (2007) found a relationship between word stress and reading in third graders; however, their study focused on stress production rather than detection. The current results support the findings by Ding et al. (2015) who found that Chinese children with poor reading skills struggled with lexical tone, which is at the supra-segmental level. Mehler et al. (1998) found that infants as young as 1 month could detect patterns of strong and weak syllables. Curtin et al. (2005) examined syllable stress and its role in phonological representations in young infants and found that syllable stress facilitated speech segmentation. This concurred with another study that found similar results in 6-month-old infants and found that 9-month-old infants can incorporate supra-segmental information with segmental cues (Bertoncini et al. 2011). Word stress can be considered as an abstract supra-segmental property of rhythmic grouping (Beyermann and Penke 2014). Holliman et al. (2010) proposed that speech rhythm sensitivity should be included in reading models for children. In many Asian countries such as China, word stress is explicitly taught when each new word is introduced (e.g., KNOWledge, reQUIRE, deCIDE) because foreign-language learners do not have the natural exposure to the pronunciation, word rhythm, and word stress. Word stress can affect phonological representation, so teaching explicit pronunciation, word rhythm, and word stress may facilitate these children's forming more accurate phonological representations.

Analysis of the linguistic manipulations of the invented spelling items found that individuals with reading difficulties are less likely to accurately spell CVCC and CCVC words than typical readers, another feature that would be important to include in a reading screening tool to differentiate between poor and typical readers. The results indicated that there was no statistically significant difference between poor readers and typical readers in their spelling accuracy with CVC words. However, there was a difference in the spelling ability with one-syllable words between these groups. CVC and CVCC/CCVC words both consist of one syllable. This indicates that while the spelling of one-syllable words could be used to differentiate between poor and typical readers, it may specifically be CVCC/CCVC words that differentiate the two groups rather than CVC words. Therefore, instruction and intervention should focus on spelling double consonants at the beginning and ending of words. This also has implications for features of screening tools for reading ability. It has been indicated that young children often have difficulties spelling certain consonant clusters before a vowel (Bruck and Treiman 1990; Read 1975) and also after a vowel (Marcel 1980; Treiman et al. 1995). Serrano and Defior (2010) investigated spelling abilities in Spanish children aged 9–16 years who had dyslexia. They found that accuracy in spelling consonant clusters was poorer in these individuals than in their typically developing peers. The current results also demonstrated that spelling ability on two- and three-syllable words differentiated between poor and typical readers. Poor readers struggled the most with three-syllable words. This indicates that this segmental level measure is an important criterion of reading difficulty screening tools. This information can also be used to inform instruction on word study, for example, categorizing words according to these spelling patterns and focusing instruction on these areas of weakness to facilitate students' automatic recognition of word patterns (Bear et al. 2008).

## Limitations and Research Implications

The findings of the current study need to be considered in light of several limitations. First, the study was conducted with a sample of 60 third graders. This was a conservative sample size and, therefore, the study would need to be replicated with a larger sample size. The sample was from two states only. Reading instruction can vary from state to state, and this limits the generalizability of the findings nationally. We examined third graders; however, a screening tool to detect reading difficulties would be needed for lower grades. The proposed tool would need to be adapted to be developmentally more appropriate for lower grades while still incorporating the aspects of linguistic manipulations proposed in the current study. For example, rather than assessing word stress awareness, assessing speech rhythm sensitivity may be more appropriate for younger children (Holliman et al. 2010). The results were correlational and, therefore, causal relationships cannot be assumed.

The present study is one of few that examines the relation between invented spelling (including aspects of supra-segmental levels of phonological awareness) and word reading. It is important to replicate the study to determine if the current findings can be reproduced and provide support for the results yielded, and to contribute further to the existing pool of literature. Poor readers were found to struggle with invented spelling; therefore, it is important to further explore its use as a diagnostic tool (Henderson 1990; Invernizzi and Hayes 2004; Ness 2010). It is also important to further explore supra-segmental cues, including word stress, to determine if they should be incorporated into a screening tool for reading. Poor readers in the current sample were defined as students who were considered by their teachers to be in the bottom 25% of their class in reading. It would be of interest to determine how those with dyslexia differ on invented spelling used in the current study. We recruited monolingual students only, but future researchers could investigate bilingual readers.

In short, this study provides evidence that not only should phonological awareness at phoneme level and RAN be considered an important component of a reading screening tool, but that segmental levels of linguistic manipulation, such as CVCC/CCVC words, syllable segmentation, and nonreal words, should be incorporated. In particular, the current results in conjunction with extant research demonstrate that exploring the role supra-segmental levels such as word stress play in the pathway from auditory perception to the processing of syllables, to phonemic processing, to decoding phonics is important. These results support the important role that word stress can play in explaining poor reading. Other aspects of supra-segmental levels of phonological awareness need to be explored to determine which aspects are contributors to successful reading. The study also proposes the utility of invented spelling as an informative instructional and diagnostic tool.

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**Compliance with Ethical Standards**

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical Standard** This study closely followed all ethical standards established by Institutional Review Board at Fordham University and participating schools.

## Appendix A

See Table 8.

**Table 8** Scoring rubric for invented spelling

| Points | Description |
|---|---|
| 0 | A random sequence of letters was provided |
| 1 | A prominent part of the word was represented using a phonetically related letter |
| 2 | The correct spelling of the initial grapheme was provided |
| 3 | More than one phoneme was represented with a phonetically related or conventional letter in the correct order |
| 4 | All phonemes were represented with phonetically related or conventional letters |
| 5 | All consonant phonemes were represented with conventional letters and representation of vowel |
| 6 | A proper conventional spelling was provided |

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