Response to Phonics Through Spelling Intervention in Children With Dyslexia

Robin van Rijthoven, Tijs Kleemans, Eliane Segers & Ludo Verhoeven

To cite this article: Robin van Rijthoven, Tijs Kleemans, Eliane Segers & Ludo Verhoeven (2021) Response to Phonics Through Spelling Intervention in Children With Dyslexia, Reading & Writing Quarterly, 37:1, 17-31, DOI: 10.1080/10573569.2019.1707732

To link to this article: https://doi.org/10.1080/10573569.2019.1707732
Response to Phonics Through Spelling Intervention in Children With Dyslexia

Robin van Rijthoven\textsuperscript{a,b}, Tijs Kleemans\textsuperscript{a}, Eliane Segers\textsuperscript{a}, and Ludo Verhoeven\textsuperscript{a}

\textsuperscript{a}Behavioural Science Institute, Radboud University, Nijmegen, The Netherlands; \textsuperscript{b}OPM, Nijmegen, The Netherlands

ABSTRACT
We examined the response to a phonics through spelling intervention for children with developmental dyslexia in word and pseudoword reading efficiency and word spelling. Furthermore, we investigated to what extent the response to the intervention is robust across different cognitive profiles (phonological awareness, rapid automatized naming, and working memory). A group of 54 Dutch children, diagnosed with developmental dyslexia, received a phonics through spelling intervention that combined reading and spelling instruction and practice in a systematic way. An equal amount of time was spent on reading and spelling. Compared with norms within a normal population, positive effects were established for word and pseudoword reading efficiency and word spelling from pretest to posttest. The individual variation in phonological awareness, rapid automatized naming, and verbal working memory did not significantly influence the progress in reading and spelling children made during the phonics through spelling intervention. It can thus be concluded that a combined reading and spelling intervention is beneficial for word and pseudoword reading efficiency and word spelling in children with developmental dyslexia notwithstanding their cognitive profiles. Although promising results were found, this study also showed the persistence of spelling but even more so of reading problems after an intervention among children with dyslexia.

Reading and spelling are essential skills in life and contribute to quality of life (Stein, Blum, & Barbaresi, 2011). It is thus crucial that all children reach sufficient reading and spelling levels. However, learning to read and spell is not an easy task for all children. To become a proficient reader and speller, an efficient recurrent network of phonological, orthographic, and semantic representations needs to be built (Seidenberg & McClelland, 1989). Previous research has consistently pointed out that bidirectional relationships between phonology and orthography are crucial for the development of both reading and spelling abilities (Bosman & Van Orden, 1997). Children with dyslexia have severe problems in building up these phonology–orthography connections (Lyon, Shaywitz, & Shaywitz, 2003), although phonics interventions have been relatively successful in strengthening these connections (for a review, see Galuschka, Ise, Krick, & Schulte-Körne, 2014). It is important to note that such interventions have mainly focused on reading
(i.e., going from orthography to phonology) rather than reading and spelling combined (i.e., going from phonology to orthography as well, but see Galuschka et al., 2014 and Johnston & Watson, 2006). The effectiveness of a so-called phonics through spelling intervention, aiming to enhance the bidirectional relationships between phonology and orthography, has not yet been demonstrated. In the current study, we therefore examined whether a phonics through spelling intervention benefits both reading and spelling in children with dyslexia and whether such effects are consistent across cognitive profiles.

**Problems in learning to read and spell for children with dyslexia**

When learning to read, children learn the principle of phonological recoding, that is to decode words by sounding out letters and blending them into words (Castles, Rastle, & Nation, 2018). With extensive practice, the orthographic and phonological representations and connections between the two get stored in memory. In learning to spell words, the reverse process (i.e., orthographic recoding) occurs. Both phonological and orthographic recoding processes build upon the bidirectional connection between phonological and orthographic representations (Bosman & Van Orden, 1997).

The strength of the bidirectional relationship and the specificity of both phonological and orthographic representations differ among children (Perfetti & Hart, 2002), with words with high-quality representations being read and spelled better than words with lower lexical quality (Perfetti, 2007; Perfetti, Liu, & Tan, 2005). Children develop reading and spelling problems when the bidirectional relations between phonological and orthographic representations are less strong (Melby-Lervåg, Lyster, & Hulme, 2012; Wimmer & Mayringer, 2002). This is especially the case for children with dyslexia. These children have missing, inaccurate, or underspecified representations caused by a phonological deficit (Conrad, 2008). As a consequence, these children have large difficulties to read words and pseudo words both accurately and fluently and spell words correctly (Lyon et al., 2003).

Research among typically developing children pointed out that combining reading and spelling during instruction can be beneficial for both learning to read and learning to spell (Conrad, 2008; de Graaff, Bosman, Hasselman, & Verhoeven, 2009; Ehri, 2000; Ehri & Wilce, 1987; Ellis & Cataldo, 1990; Fitzgerald & Shanahan, 2000; Ise & Schulte-Körne, 2010; Ouellette & Sénéchal, 2008). Such results emphasize the importance of high-quality bidirectional relationships of orthographic representations in learning to read and spell. As a case in point, Ouellette and Sénéchal (2008) found that kindergarten children who received combined reading and spelling instruction showed a more analytical approach and better integration of phonological and orthographic knowledge which benefited their reading as well as their spelling development after a 4-week training. A transfer effect from training spelling on reading development has also been evidenced (Conrad, 2008; Ehri, 1989; Graham & Hebert, 2011; Ise & Schulte-Körne, 2010; O’Connor, Jenkins, & Slocum, 1995; Ouellette, Martin-Chang, & Rossi, 2017), which suggests that the addition of spelling instruction and practice may result in more refined representations as compared to only focusing on reading abilities. For instance, Ehri (1989) found that better spelling leads to more fluent and automatic word identification skills and thus better word reading accuracy due to the necessity of having high-quality representations for spelling. This necessity arises from the fact that spelling is more difficult to learn than reading (Bosman & Van Orden, 1997; Ehri, 1997; O’Connor et al., 1995).

**Interventions on reading and spelling**

There is a large research base on interventions for struggling readers. A recent meta-analysis by Galuschka and colleagues (2014) pointed out that a phonics intervention is generally most
effective with significant effects on word reading and pseudoword reading with a transfer to spelling levels. However, most phonics interventions focus on reading and do not combine reading and spelling instruction in one intervention. Only a few studies investigated the benefits of a phonics through spelling intervention (Galuschka et al., 2014).

To begin with, Lovett, Ransby, Hardwick, Johns, and Donaldson (1989) randomly assigned 178 poor-reading children between the ages of 8 and 13 years to phonics instruction with writing activities, a language stimulation program, or a control condition. Both experimental conditions led to improvement in word reading and writing but not in pseudoword reading. The phonics intervention including writing activities, however, showed better generalization of skills to untrained words. In another study, Lovett, Warren-Chaplin, Ransby, and Borden (1990) tested two versions of phonics instruction with writing activities. In a group of 54 disabled readers, a whole-word training was compared to a whole-word training supplemented with phonological and orthographic recoding. Both conditions included writing activities and showed significant effects on word reading accuracy and fluency and word spelling. Pseudoword reading was not included in this study. The training with the whole-word approach showed more transfer to untrained content. Finally, Kirk and Gillon (2009) tested the effectiveness of a training by sorting tasks and spelling with prompts with a control condition among 16 children with spelling problems. The experimental group significantly gained in pseudoword reading and spelling accuracy and was able to generalize their trained skills to new words. No effects were found on word reading.

Two studies examined the benefits of adding spelling activities to a phonics intervention for children with dyslexia in the Netherlands. Tilanus, Segers, and Verhoeven (2016) examined a group of 54 children with dyslexia, who had received a 12-week intervention. Approximately one-third of the instruction time was spent on writing activities. Compared to typically developing peers, positive effects were found of this intervention on pseudoword reading accuracy and efficiency and spelling, but not on word reading accuracy or efficiency. Furthermore, Tijms (2011) tested the effectiveness of a computer-based phonics intervention including both reading and spelling activities among 99 children diagnosed with dyslexia. Significant gains were found, and after the intervention word reading accuracy and spelling levels were comparable to the lower bound of normal range.

Robustness of the intervention

Not all children with dyslexia benefit from phonics interventions to the same extent, and individual differences in responsiveness have been reported repeatedly (see, e.g., Galuschka et al., 2014; Singleton, 2009; Snowling & Hayiou-Thomas, 2006; Torgesen, 2006). Attempts have been made to relate the responsiveness to intervention to the cognitive profile of the child. Given the fact that dyslexia can be characterized by an underlying phonological deficit, phonological awareness, rapid automatized naming, and verbal working memory are generally considered cognitive precursor measures that may also predict children’s responsiveness to intervention (Shaywitz et al., 2003; Snowling, 1998). In line with the double deficit hypothesis (as described by Wolf & Bowers, 1999), it is argued that phonological awareness and rapid automatized naming can be seen as critical sources of reading impairment (Landerl & Wimmer, 2008).

Prior research on the robustness of response-to-intervention effects showed that decoding accuracy training effects were sustained across individual differences in phonological awareness (Felton, 1993; Tijms, 2011) and that reading fluency training was robust across individual differences in rapid automatized naming training (Heikkilä, 2015). Combining accuracy and fluency training also showed robustness across individual differences in both phonological awareness and rapid automatized naming (Aravena, Tijms, Snellings, & van der Molen, 2016; Tilanus et al., 2016). Responsiveness to intervention may also be dependent on children’ verbal working
memory. A limited verbal working memory reduces the amount of phonological and orthographic information that can be co-activated during the reading process, especially during the decoding process (Gathercole & Baddeley, 1993; Perez, Majerus, Mahot, & Poncelet, 2012). Hulme (1987) and de Jong (1998) argued that constraints in verbal working memory negatively influence phonological decoding skills since during decoding many segments must be held in memory. However, the effect of verbal working memory on the progress during reading and spelling interventions has received scant attention. Tijms (2011) found verbal working memory to be a significant moderator for reading abilities and not for spelling, whereas Tilanus et al. (2016) did not find direct effects of verbal working memory on reading and spelling outcomes.

The present study

From the research conducted so far, it can be concluded that the reading and spelling abilities of children with reading and spelling problems could benefit from the addition of spelling to a phonics intervention. However, the effectiveness of a phonics through spelling intervention in which an equal amount of time is devoted to spelling and reading is still unknown. Given the fact that children with dyslexia have problems in forming strong bidirectional relations between phonology and orthography, a phonics through spelling intervention could indeed enhance the reading and spelling abilities of children with dyslexia. Furthermore, little is known about the robustness of a phonics through spelling intervention in respect of the cognitive profile of the child. The purpose of the present study was, therefore, to measure the responsiveness of a phonics through spelling intervention among Dutch children with dyslexia. It can be hypothesized that an effect of the quality of the bidirectional relationships between phonological and orthographic representations is highly prominent in the case of a transparent orthography like Dutch. In order to find out more about the robustness of this Dutch phonics through spelling intervention, the role of individual differences among children with dyslexia will also be taken into account. Specifically, we addressed the following research questions:

1. What is the effect of a phonics through spelling intervention on pseudoword reading, word reading, and word spelling scores in Dutch children with dyslexia?
2. To what extent are the outcomes of a phonics through spelling intervention robust across different cognitive profiles?

Given the fact that spelling contributes to the deeper knowledge of our sound system and prior research found transfer effects of spelling to reading, we expected that children with dyslexia would show a substantial change in their reading and spelling skills after the phonics through spelling intervention. Second, based on prior research, we expected the phonics through spelling intervention outcomes to be robust across differences in phonological awareness, rapid automatized naming, and verbal working memory.

Method

Participants

Participants were Dutch children diagnosed with developmental dyslexia who received an in-service phonics through spelling intervention in a clinic for assessment and intervention for children with learning difficulties. For the purpose of this study, 99 files of Dutch children were collected from the clinic. Due to missing data and different instruments, a sample of 54 children (37 boys and 17 girls) with Dutch as their first language was selected for this study.
The mean age of this group of children at the start of the assessment was 8.97 years ($SD = .96$). Children were in grade 2 ($n = 17$), grade 3 ($n = 24$), grade 4 ($n = 9$), grade 5 ($n = 3$), and grade 6 ($n = 1$). Out of the group of 54 children, 17 children attended the same class an extra year. All children had perceptual cognitive capacities within the normal range (mean = 103.70, $SD = .15$). However, since there was variation in perceptual cognitive capacities, this variable was included as a control variable in the analysis. Parents gave active consent to use the data collected during the intervention for research purposes.

**Procedure**

The current study was based on existing data collected by a clinic for assessment and intervention for children with learning disorders. Between 2009 and 2013, data were filed in this clinic. All children had been referred to this clinic by their parents and teachers. The assessment and intervention were performed following the standardized Dutch Protocol Dyslexia Diagnostics and Treatment (Blomert, 2006). The following procedures were followed: Assessment started with parents and teacher filling in questionnaires about current problems and child’s development. Afterward parents were invited for an interview at the clinic. Both the questionnaires and the interview were in order to rule out other explanations for reading and spelling problems, such as general learning problems or specific influential events during the child's development with impact on learning progress. Furthermore, by means of the questionnaires teachers had to prove constant weak performances for 1.5 years (word reading scores below 10th percentile or below 15th percentile combined with spelling scores below 10th percentile) for these children notwithstanding systematic and well-defined reading and spelling instruction in the classroom. This should be supplemented with in-class extended instruction time, combined with individual intervention (i.e., remedial teaching) for 10 to 12 weeks. All children were tested two consecutive mornings (9:00–12:00 a.m. including breaks) by experienced MSc-graduated clinicians. Rapid automatized naming, phonological awareness, verbal working memory, pseudoword decoding, word decoding, spelling, and perceptual cognitive skills were measured. Two or three weeks after the assessment the phonics through spelling intervention started. After the intervention all participants received the posttest, including pseudoword decoding, word decoding, and spelling measures.

**Outcome measures**

**Pseudoword decoding**

Pseudoword decoding was measured with the Klepel (van den Bos, Lutje Spelberg, Scheepstra, & de Vries, 1994). Children are asked to read as many meaningless words correctly as possible within a time limit of 2 minutes. This task consists of 116 unrelated non-words presented in four rows on one sheet. The words all have the same structure as meaningful words. Words become more difficult gradually from one syllable (“taaf”) up to five syllables (“nalleroonplinteng”). Efficiency measure (i.e., total number of words read within 2 minutes minus number of errors) was calculated. The reliability of this measure differs per age but is at least .89 (van den Bos et al., 1994). Pseudoword decoding was measured before and after the intervention.

**Word decoding**

Word decoding was measured with the Brus One Minute Test (Brus & Voeten, 1973). Children were asked to read as many meaningful words correctly as possible within a time limit of 1 minute. This task consists of 116 unrelated words presented in four rows on one sheet. Words become more difficult gradually from one syllable (“waar” [true]) up to four syllables
(“tekortkoming” [shortcoming]). Efficiency measure (i.e., total number of read words minus number of errors) was calculated. The reliability of this measure differs per age but is at least .87 (van den Bos et al., 1994). Word decoding was measured before and after the intervention.

**Word spelling**

Word spelling was measured with the PI word dictation (Geelhoed & Reitsma, 2000). In this task children were asked to write single words correctly. The dictation consisted of 135 words, divided into 9 blocks of 15 words. First a sentence was read aloud and afterward the target word was repeated. The test was terminated when a child failed to write at least 8 words correctly. The number of correctly written words was counted. The reliability of this measure differs per age but is at least .91 (Geelhoed & Reitsma, 2000). Word spelling was measured before and after the intervention.

**Predictor measures**

**Phonological awareness**

Two subtests from the Screening Test for Dyslexia were used. First, during “Phoneme Deletion” (Kort, Schittekatte, van den Bos et al., 2005), children were asked to omit a phoneme from an orally presented word and speak out the remaining word (e.g., “dak” [roof] minus “k” [f] is “da” [roo]). Testing was terminated after four consecutive mistakes. Second, during the subtest “Spoonerism” (Kort, Schittekatte, van den Bos et al., 2005), children had to switch the first sounds of two words (e.g., “John Lennon” becomes “Lohn Jennon”). Testing was terminated after five consecutive mistakes. The reliability differs per age but is at least .60 (Kort, Schittekatte, van den Bos et al., 2005). In both tests, all correctly formed words were counted.

**Rapid automatized naming**

Rapid automatized naming was measured using two subtests of Continuous Naming and Reading Words (van den Bos & Lutje Spelberg, 2010). First, during “Naming Letters,” children had to read out loud 50 letters. Second, during “Naming Digits” they were asked to read out loud 50 digits. Children were asked to name these visual stimuli as quickly as possible. The time in seconds needed to finish each subtest was used for analysis. A low score therefore represented a good performance. The reliability of this measure differs per age but is at least .75 (van den Bos & Lutje Spelberg, 2010).

**Verbal working memory**

Verbal working memory was measured using the backward task of the Number Recall subtest from the Wechsler Intelligence Scale for Children-III (WISC-III) (Kort, Schittekatte, Dekker et al., 2005). In this task, the experimenter pronounces sequences of digits that the child was asked to repeat in backward order. Testing was terminated after two consecutive mistakes. The number of correctly recalled sequences was counted. The reliability of this measure differs per age but is at least .50 (Kort, Schittekatte, Dekker et al., 2005).

**Perceptual cognitive skills**

Perceptual cognitive skills were measured by adding the z scores of four subtests from the WISC-III (Kort, Schittekatte, Dekker et al., 2005). First, during “Incomplete drawings,” the child has to name or point at a missing part in a drawing of familiar objects or situations within 30 seconds. Testing was terminated after five consecutive mistakes. The child received one point
for each item. All points were counted afterward. The reliability differs per age but is at least .54 (Kort, Schittekatte, Dekker et al., 2005).

Second, during “Picture organisation,” the child has to put pictures in the right order to make the story depict right. The child was asked to do this as quickly as possible. Testing was terminated after three consecutive mistakes. The first two items are scored two points at first attempt and one point at second attempt. The other items were given zero, two, three, four, or five points based on accuracy and the time the child needs to order the pictures. The last item was give one point when the order was reversed. All points were counted afterward. The reliability differs per age but is at least .65 (Kort, Schittekatte, Dekker et al., 2005).

Third, during “Block design,” the child had to reconstruct patterns of two, four, and later nine blocks shown on a picture. The child was asked to do this as quickly as possible. Testing was terminated after two consecutive attempts. The first three items are scored two points at first attempt and one point at second attempt. The other items were given four, five, six, or seven points based on accuracy and the time the child needs to reconstruct the pattern. All points were counted afterward. The reliability differs per age but is at least .71 (Kort, Schittekatte, Dekker et al., 2005).

Fourth, during “Visual puzzles” the child has to make five puzzles of everyday objects. Testing was terminated after four consecutive mistakes. Each right connection between puzzle pieces was given one point. Extra points were given when less time was needed to make the puzzle, with a maximum of ten points. All points were counted afterward. The reliability differs per age but is at least .40 (Kort, Schittekatte, Dekker et al., 2005).

**Phonics through spelling intervention**

The aim of the phonics through spelling intervention was to reach a functional level of technical reading (given their age) and spelling (given their class) by means of combining reading and writing into one intervention. The intervention meets the criteria of the standardized Dutch Protocol Dyslexia Diagnostics and Treatment (Blomert, 2006). Children had a weekly 45-minute session with a clinician. The mean length of the intervention was 27.06 weeks ($SD = 4.79$). Variation in the length of the intervention occurred due to variation in time needed to acquire the 80% accuracy levels as described earlier. During these sessions, the clinician tailored the intervention as much as possible to each child’s needs. Explicit direct instruction, guided exercises, and feedback were given according to each child’s needs. Approximately half of the time was spent on reading activities and the other half of the time was spent on spelling activities. The continuity of quality during assessment and intervention was guaranteed by supervision of certified clinical health psychologists. The intervention included three parts.

**1) Grapheme–phoneme correspondence (GPC)**
Both reading and spelling started with practice of GPC. The GPCs a child found difficult were identified and practiced using mnemonic cards. When the child read or wrote all GPCs correctly, the child was asked to accelerate by decreasing the time a flashcard was shown and accelerate the speed of letter dictation. In the end, the child had to name every letter in one second. All GPCs, including combinations of letters that were associated with phonemes, were presented on a mnemonic card and divided into categories (e.g., vowels that sound long vs. vowels that sound short).

**2) The alphabetical principle in writing and reading (accuracy and efficiency)**
The next phase of treatment was the use of letter knowledge in reading and writing words. At first, children learned to write words using a four-step strategy: repetition of the auditory offered word, dividing the word into individual phonemes, writing the individual phonemes one-by-one
until the word was finished, and finally checking the written word by reading it out loud. In the beginning, children had to write simple words (e.g., CVC, CVVC), but difficulty gradually increased (e.g., CCVVV, CCVVVC, CCCVCC). When children mastered these levels, the same five-step strategy was used but now dividing/writing in syllables instead of individual phonemes.

At the same time, reading words was practiced by naming words using flashcards. Depending on their level of reading ability, children were asked to spell the word and then sound out the word or directly sound out the word. At first, only accuracy was trained and later on also efficiency was trained. During the intervention, the difficulty of words on the flashcards gradually increased based on the child’s reading level. The trained words again appeared in reading texts. The text was read repeatedly to stimulate accuracy and efficiency. Feedback was given on accuracy and later also on efficiency. When word reading became more difficult, text reading shifted to higher levels as well.

(3) Rules and exceptions

Dutch is a rather transparent language, but still rules and exceptions need to be learned to write and read words (mostly polysyllabic words) correctly. In spelling four main rules were taught. First, the writing of words that end on the phoneme /t/ was learned. In Dutch these words can be written with “t” or “d” on the end of the word (e.g., hond [dog], boot [ship]). By making a word plural it is possible to hear a “t” or a “d” (e.g., honden, boten). Whatever consonant is heard in the plural form must be written in the singular word as well. The second category concerns words with /gt/, which can be written as “gt” or “cht” (e.g., zaagt [sweeps], lucht [air]). Whenever a short sound vowel is placed before /gt/, then a “cht” needs to be written (lucht). The third and fourth rules were combined because for both rules words need to be divided into syllables. When a syllable ends with a short vowel this is written short (raa-men → ra-men [windows]), but when it ends with a short vowel the next consonant is doubled (ki-pen → kippen [chickens]).

In this phase of the intervention, children also read polysyllabic words and thus needed to understand that the third and fourth spelling rules also apply to reading. The word ramen shows a short vowel but it needs to be read as a long vowel (raa-men) and when a double consonant is sighted the vowel can be read short as well, but the consonant must be read only once (ki-pen).

Additional rules for spelling and reading were taught according to each child’s needs. In order to rehearse the above-mentioned spelling and reading knowledge children had to do some home exercises both for reading as well as spelling. Parents were asked to train four times a week during 15 minutes with prescribed exercises. Parents kept a log, provided by the clinician. Based on this log, the clinician could move forward or give more attention to certain topics. When a child reached an accuracy of 80% during practice (read or write 80% of the words correctly) the clinician moved on to the next topic or phase of intervention. Therefore, variation in the length of the program is present.

**Analytic approach**

All outcome measures were measured before and after the intervention and both pre- and posttest scores were standardized compared to norm-based peers using percentile scores at the time of testing. To answer the second research question, we calculated the individual mean change per session (both with raw and percentile scores) by subtracting pre- from posttest scores. Following Gollwitzer, Christ, and Lemmer (2014) change scores are reliable when two requirements are met. First, standard deviations must differ between measurement occasions. Second, there needs to be a non-zero variation in observed difference scores in order to define the reliability. In order to rule out the effects of variation in the length of the intervention, the individual change score was divided by the number of sessions the intervention for each individual lasted. Working with change
scores implied that the differences in individual pretest scores were not taken into account. Pretest scores were included as a control variable to control for variation.

Results

Descriptive statistics

Table 1 presents the descriptive statistics (means, standard deviations, and range) of all study measures. Both pre- and posttest scores are given of all outcome measures in raw scores and percentile scores. These percentiles scores are based on norms within the normal population. At the start of the intervention the mean scores were below the 10th percentile on pseudoword reading, word reading, and word spelling, while afterward these mean scores were above the 10th percentile on all three measures. Furthermore, raw scores and age-based standardized scores are reported for all the predictor measures. Finally, the change scores and change scores per session were calculated. Both requirements as reported by Gollwitzer et al. (2014) were met since the standard deviations has increased after the intervention and the differences scores were all positive and thus non-zero. Reading and spelling boxplots before and after the phonics through spelling intervention can be seen in Figure 1.

Correlations among all study variables are presented in Table 2. As can be seen, phonological awareness was significantly correlated with word decoding posttest percentile scores and word spelling posttest percentile scores. Rapid automatized naming correlated significantly with word decoding pretest and posttest percentile scores, whereas verbal working memory did not correlate significantly with any criterion measure. With respect to the covariates, both perceptual cognitive skills and spelling pretest scores were significantly related to spelling posttest percentile scores.
Phonics through spelling intervention effects

First, the effect of the intervention was established by determining response to intervention for each child. Based on the normal distribution and the correction for time, typically developing children would have the same percentile score at pre- and posttest. Positive mean change scores per session among the children with dyslexia therefore would indicate a response to intervention. Table 1 presents the descriptive statistics for the percentile scores and the change scores for all dependent variables. The mean change scores are positive for all dependent measures. Paired-sample \( t \) tests, using Holm–Bonferroni correction (Holm, 1979), were used to test whether a change was significant. Holm–Bonferroni procedure was used to adjust the critical \( p \) value to control for the Type 1 error (see Abdi, 2010). Pseudoword posttest percentile scores were significantly higher than pretest percentile scores (\( t (43) = -3.927, \) adjusted \( p = .017, d = 0.51 \)). Similar positive effects were found for posttest versus pretest percentile scores of word reading (\( t (52) = -3.453, \) adjusted \( p = .025, d = 0.47 \)) and word spelling (\( t (52) = -3.137, \) adjusted \( p = .050, d = 0.59 \)). Pretest and posttest differences are depicted in boxplots in Figure 1. Out of all children, 49.1% were no longer among the lowest 10% for spelling. For pseudoword reading this was 26.1% and for word reading 29.6%.

Table 2. Pearson correlations between the predictor measures (i.e., length of intervention, perceptual cognitive skills, age, working memory, phonological awareness, and rapid automatized naming) and criterion measures (i.e., percentiles scores of pseudoword decoding pretest/posttest, word decoding pretest/posttest, and spelling pretest/posttest) (\( n = 54 \)).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>.277*</td>
<td></td>
<td>.108</td>
<td>.066</td>
<td>-.136</td>
<td>-.287*</td>
<td>-.004</td>
<td>.102</td>
<td>.010</td>
<td>.070</td>
<td>.200</td>
</tr>
<tr>
<td>2. Perceptual cognitive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>skills</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Phonological awareness</td>
<td>.277*</td>
<td></td>
<td>.108</td>
<td>.066</td>
<td>-.136</td>
<td>-.287*</td>
<td>-.004</td>
<td>.102</td>
<td>.010</td>
<td>.070</td>
<td>.200</td>
</tr>
<tr>
<td>5. Rapid automatized</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>naming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Verbal working memory</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Pseudoword decoding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pretest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Pseudoword decoding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>posttest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Word decoding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pretest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Word decoding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>posttest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Word spelling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pretest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Word spelling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>posttest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Boxplots of pretest and posttest scores of word decoding, pseudoword decoding, and word spelling score.

Phonics through spelling intervention effects

First, the effect of the intervention was established by determining response to intervention for each child. Based on the normal distribution and the correction for time, typically developing children would have the same percentile score at pre- and posttest. Positive mean change scores per session among the children with dyslexia therefore would indicate a response to intervention. Table 1 presents the descriptive statistics for the percentile scores and the change scores for all dependent variables. The mean change scores are positive for all dependent measures. Paired-sample \( t \) tests, using Holm–Bonferroni correction (Holm, 1979), were used to test whether a change was significant. Holm–Bonferroni procedure was used to adjust the critical \( p \) value to control for the Type 1 error (see Abdi, 2010). Pseudoword posttest percentile scores were significantly higher than pretest percentile scores (\( t (43) = -3.927, \) adjusted \( p = .017, d = 0.51 \)). Similar positive effects were found for posttest versus pretest percentile scores of word reading (\( t (52) = -3.453, \) adjusted \( p = .025, d = 0.47 \)) and word spelling (\( t (52) = -3.137, \) adjusted \( p = .050, d = 0.59 \)). Pretest and posttest differences are depicted in boxplots in Figure 1. Out of all children, 49.1% were no longer among the lowest 10% for spelling. For pseudoword reading this was 26.1% and for word reading 29.6%.
Robustness of the intervention

Second, the robustness for variation in individual cognitive profiles of a phonics through spelling intervention in a rather transparent orthography was examined by multiple linear regressions. Table 1 presents the descriptive statistics for both raw and percentile scores of the individual change per session. In the multiple linear regressions, for all outcome measures percentile scores were used to control for age, as the children in this study vary in age.

We performed three multiple linear regression analyses (one for each outcome variable). Variables were added in three steps. The predictor variables (i.e., phonological awareness, rapid automatized naming, verbal working memory) were entered in Step 1, followed by perceptual cognitive skills in Step 2 to control for variation in perceptual cognitive skills. Finally, in Step 3, pretest percentile scores were entered to see variation at the start of the intervention predicted the mean change per session during the intervention.

No significant effects of the three main precursors (phonological awareness, rapid automatized naming and verbal working memory) were found on spelling and pseudoword and word reading. In other words, the change per session could not be predicted from individual variation in precursor measures, and the intervention seems therefore robust for variation in the cognitive profiles. The control variables perceptual cognitive skills and pretest scores did not influence the mean change per session for reading. However, for spelling, this was the case. First, the higher the scores on perceptual cognitive skills, the larger the change per session on spelling. Second, the lower the pretest percentile score, the larger the change per session on spelling. Table 3 depicts the results.

Conclusions and discussion

The present study investigated the effect of a phonics through spelling intervention in children with developmental dyslexia. Two research questions were addressed. The first was on the changes in pseudoword reading, word reading, and word spelling scores in Dutch children with dyslexia after a phonics through spelling intervention. The second research question addressed whether the phonics through spelling intervention is robust for individual variation in cognitive
Profiles consisting of phonological awareness, rapid automatized naming, and verbal working memory in a transparent orthography.

With respect to the first research question, it was found that on average children with dyslexia responded to the phonics through spelling intervention; their standardized scores (i.e., scores that were based on typically developing peers) on pseudoword reading, word reading, and word spelling significantly improved as compared to their corresponding pretest scores. The goal of the intervention was to elevate the children to a higher level of spelling and reading performances. Elevating these children from the lowest 10% group is an important step. As mentioned in the results, out of all children 49.1% were no longer among the lowest 10% for spelling. For pseudoword reading this was 26.1% and for word reading 29.6%. A substantial group of children thus remains in the lowest 10%, which highlights the resistance to treatment among children with dyslexia (e.g., Alexander & Slinger-Constant, 2004; Galuschka et al., 2014; Tilanus, Segers, & Verhoeven, 2019; Torgesen, 2006). However, the positive effects also show that gains can be made. This is in line with previous findings about the effectiveness of phonics interventions (e.g., Galuschka et al., 2014) and the combination of both reading and spelling in instructions among typically developing children (Conrad, 2008; Ehri & Wilce, 1987; Ellis & Cataldo, 1990), children with reading and spelling problems (Kirk & Gillon, 2009; Lovett et al., 1989, 1990; Ouellette & Sénéchal, 2008), and children diagnosed with dyslexia (Tijms, 2011; Tilanus et al., 2016). The fact that we found positive effects on both spelling and reading (word or pseudoword reading) supports the hypothesis that combining spelling and reading in one intervention is beneficial for reading and spelling development of children with dyslexia. It shows that a focus of the intervention on the bidirectional relation between orthographic and phonological representations has a positive impact on both reading and spelling development (Ouellette & Sénéchal, 2008). The positive outcomes of this phonics through spelling intervention should be evaluated against positive effects on word spelling and rather inconsistent findings of reading-focused interventions on pseudoword and word reading (Kirk & Gillon, 2009; Lovett et al., 1989, 1990; Tijms, 2011; Tilanus et al., 2016). In contrast, our study showed that a phonics through spelling intervention that devoted time equally to reading and spelling instruction has positive effects on spelling as well as on both pseudoword and word reading. It is evidenced that a combined reading and spelling instruction helps build strong bidirectional relations between phonology and orthography and thereby benefits reading and spelling development.

With respect to the second research question, it was shown that the results of the intervention on word reading, pseudoword reading, and spelling after a phonics through spelling intervention were robust for variation in cognitive profiles (e.g., phonological awareness, rapid automatized naming, and verbal working memory). In other words, the phonics through spelling intervention on average appears to work notwithstanding the variation in cognitive-linguistic profiles within the group of children with dyslexia. These findings are in line with other studies demonstrating the robustness of reading interventions focusing on decoding accuracy training for phonological awareness (Felton, 1993; Tijms, 2011), fluency training for rapid automatized naming (Heikkilä, 2015), and the combination of both decoding accuracy and fluency into one training for phonological awareness, rapid automatized naming (Aravena et al., 2016; Tilanus et al., 2016), and verbal working memory (Tilanus et al., 2016).

It is interesting to note that the variation in perceptual cognitive skills and pretest scores did not influence the pseudoword or word reading change scores. Both control variables had small but significant effects on spelling change scores. The positive effect of perceptual cognitive skills found on spelling is in line with finding among normally developing children (Landerl & Wimmer, 2008). The negative effect of spelling pretest scores on the change in spelling scores after a phonics through spelling intervention could indicate a small but significant reverse Matthew effect. This is in line with findings from Aarnoutse, van Leeuwe, Voeten, and Oud (2001), who found that low performers in spelling benefit most from instruction. It is possible.
that the children with lower spelling scores at pretest had more trouble building up a strong and bidirectional network of phonological and orthographic representations by themselves. The phonics through spelling intervention may have helped them to build this network and thereby overcome some of the problems.

The unique character of the present study is the relatively large amount of time spent on spelling in order to strengthen the bidirectional relation between phonological and orthographic representations as described by Bosman and Van Orden (1997). Although children in this study significantly improved and many were no longer among the weakest 10% in word reading and spelling, it is important to note that most children remain weak readers and spellers compared to normally developing controls and large variation in reading and spelling levels is present even after the intervention. Interestingly, posttest scores, and not pretest scores for word decoding and word spelling were found to be related to phonological awareness that is seen as a prime indicator of a phonological deficit in children with dyslexia (Shaywitz et al., 2003; Snowling, 1998). It can tentatively be concluded that the phonics through spelling intervention helped children with dyslexia to overcome their reading and spelling problems up to the level of their genetically disposed phonological deficit.

Some limitations should be acknowledged at this point along with directions of future research. To begin with, although the positive effects of the phonics through spelling intervention are based on standardized norms (i.e., comparisons with typically developing peers), the results should be interpreted carefully as we did not include control groups in our study. Our study shows on average promising results for children with dyslexia after a phonics through spelling intervention. More research is necessary to find out whether these are due to the addition of spelling to the intervention. Despite these promising results, the majority of the children remain in the lowest 10%, particularly for pseudoword and word reading. More research is needed to find out what causes the differences in growth during the intervention. Future studies should consider larger samples sizes and control conditions that focus on reading solely and spelling solely. For studies combining reading and spelling in a phonics through spelling intervention, it is important to report the amount of time spent on reading or spelling separately and variations in spelling approaches that mirror phonics approaches (e.g., analytical versus synthetic approaches).

To conclude, the present findings show that phonics through spelling interventions help children with dyslexia to improve their pseudoword reading, word reading, and spelling levels. On average, the intervention is effective, notwithstanding children’s individual cognitive profiles. Perceptual cognitive skills and pretest scores predicted the change in word spelling during the intervention. Although promising results were found, this study also showed the persistence of spelling but even more so of reading problems after an intervention among children with dyslexia.

ORCID

Robin van Rijthoven http://orcid.org/0000-0002-2800-1246

References


