Journal of School and Educational Psychology
2025, Vol. 5, No. 1, 1-17
https://doi.org/10.47602/josep.v5i1.68
https://journalofschoolpsychology.com

RESEARCH ARTICLE

Dynamic and Conventional Testing of Reading and Writing in Typically Developing Children and Children Diagnosed with Dyslexia

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Abstract

This study aimed to evaluate the effectiveness of a dynamic reading and writing test in typically developing children and children diagnosed with dyslexia. In addition, this study analysed the patterns of relations between the dynamic reading and writing test with conventional tests of reading, writing and intelligence. A pre-test-training-post-test design was employed with a control condition (n = 37) receiving training after the post-test and an experimental condition (n = 43) receiving training after the pre-test. During training, children engaged in dynamic reading and writing tasks under the guidance of an adult. The training process involved visual materials and verbal explanations to enhance learning and comprehension. Generally, both typically developing children and children diagnosed with dyslexia showed equal levels of improvement from the pre-test to the post-test. Specifically, the experimental group demonstrated a training effect in the Prosodic Awareness subtest. Moreover, the dynamic reading and writing measures were associated with the conventional reading and spelling measures and intelligence. Implications for education and clinical dyslexia interventions are discussed.

Keywords: dynamic testing, reading, writing, dyslexia, training

Introduction

In many countries, static assessment tools assess scholastic performance, which typically involves a single-administration format and requires children to solve tasks independently following standardised instructions. While these tests offer straightforward administration and easily interpretable results, they often provide insight into what knowledge and skills a child has acquired through past learning experiences (Resing et al., 2020). However, they may not accurately predict future learning, potentially leading to misclassification of children with reading and writing difficulties, for example, due to false positives or ceiling effects (Bridges & Catts, 2011). Dynamic testing provides an alternative approach by measuring children's potential for learning (Dixon et al., 2022), by integrating instruction or training into the assessment or testing process to measure improvement (Resing et al., 2020) and identify specific educational needs (Cho et al., 2012). Despite growing interest in dynamic testing (Navarro & Lara, 2017; Resing & Elliott, 2010), its application in educational settings remains limited (Navarro & Lara, 2017; Resing et al., 2020). Studies mainly focused on phonological awareness or decoding skills in Kindergarten and first-grade children (Dixon et al., 2022). This study adds to the literature on dynamic testing with a novel perspective, as it combines dynamic testing of reading and writing in one test while focusing on children aged between seven and nine. The current study aimed to gain insight into the use of a new dynamic reading and writing test in the Netherlands amongst typically developing children and those diagnosed with dyslexia.

Dynamic testing of reading and writing

Dynamic testing involves various assessment techniques (Elliott & Resing, 2015; Resing et al., 2020) rooted in Vygotsky's theory of the zone of proximal development (ZPD; Navarro & Lara, 2017; Resing et al., 2020). The ZPD can be defined as the difference between the child's ability to solve a task independently and the ability to

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solve a task with the help of a more competent person (Vygotsky, 1980). By tapping into the ZPD, dynamic tests gain an insight into the learning process (Navarro & Lara, 2017; Vogelaar et al., 2017) and an indication of a child's potential for learning (Gellert & Elbro, 2017; Resing et al., 2020). As such, these tests often offer valuable information on a child's responsiveness to new information, training or instruction (Dixon et al., 2022), the type and amount of help needed during training, and the retention of newly learned information (Resing et al., 2020).

While dynamic tests traditionally focused on cognitive-intellectual domains (Mata et al., 2017; Navarro & Mora, 2011), such as inductive reasoning tasks (Resing et al., 2019; Tzuriel, 2011; Veerbeek et al., 2019), there is a growing interest in their application to academic domains such as reading and writing. However, research on dynamic tests in reading and writing after formal reading instruction in school has started is still scarce (Dixon et al., 2022). Existing studies primarily focus on pre-reading or literacy skills, using dynamic screening instruments to predict future reading and writing achievement (Cho et al., 2019; Gellert & Elbro, 2017). Studies have shown that dynamic testing results can effectively predict reading difficulties (Fuchs et al., 2011; Gellert & Elbro, 2017) and differentiate between typically developing children and those with dyslexia. For example, a Dutch study demonstrated the potential of a dynamic test to differentiate between these groups in learning letter-speech sound correspondences, which in turn correlated to the static rapid automatised naming and phonological awareness tests and predicted variance in writing and reading abilities (Aravena et al., 2017).

Reading and writing

Reading is a complex psycholinguistic skill requiring interaction between several systems: visual, phonological, semantic and orthographic (Serrano et al., 2016). In addition, several cognitive and non-cognitive skills and processes are involved in reading fluently, including perception, attention, motivation and working memory (Peng et al., 2019). Furthermore, reading requires phonological and prosodic awareness (Melby-Lervåg et al., 2012; Serrano et al., 2016). Phonological awareness can be defined as recognising and manipulating word sounds (phonemes). Teaching children to read implies learning the complex skill of discriminating between phonemes (Serrano, 2015). Research suggests that dynamic phonemic awareness interventions in young children contribute to increasing phonological skills (Bridges & Catts, 2011).

Prosodic awareness (rhythm perception) is the capability to hear an accent or indicate, manipulate, and recognise the emphasis in a word (Serrano et al., 2016). It is fundamentally relevant to the development of verbal language and, because of that, written language and learning to read (Serrano et al., 2016). Therefore, training prosodic awareness is connected to improvement in reading and writing (Serrano et al., 2016). Learning to write is also a demanding task, requiring considerable cognitive effort (Galuschka et al., 2020). For example, keeping a mental graphic representation of the word is essential in writing homophones to spell the word adequately. After all, the child cannot rely on a writing rule to determine the correct writing of a context-dependent word. Moreover, it is necessary to retrieve the writing skills or knowledge of the word (stored in the lexicon) to write the word correctly (Serrano & Defior, 2008). Writing skills complement phonemic and prosodic skills (Galuschka et al., 2020).

Furthermore, excellent orthographic representations are needed for writing because the writer needs precise knowledge of all the letters in a word (Perfetti & Hart, 2002). Therefore, an insight into speech sound-letter correspondences is fundamental, demonstrating the nature of the relationship between writing difficulties and difficulties with phonological awareness (Aravena et al., 2017). Furthermore, poor phonological awareness (Aravena et al., 2017) is often associated with specific learning disabilities such as dyslexia (Galuschka et al., 2020).

Dyslexia

Developmental dyslexia is a specific, neurodevelopmental language-based learning disability characterised by difficulties with fluent and accurate word recognition, poor decoding and writing abilities, despite adequate instruction, appropriate education/targeted interventions and intact sensory abilities (Lyon et al., 2003; Snowling, 2012). Yang et al. (2022) recently estimated the worldwide prevalence of dyslexia in primary school children to be between 6.27 and 7.97 per cent, with a lower prevalence in girls. Often, the phonological deficit theory is used to explain the occurrence of dyslexia (Aravena et al., 2017; Melby-Lervåg et al., 2012; Peterson & Pennington, 2012; Snowling, 2012). In this theory, reading and writing difficulties are explained by language skill problems, particularly deficits in poor phonological representations (Snowling et al., 2020). These deficits are already observed in young children. Other potential explanations for dyslexia include weaknesses in verbal short-term memory, processing speed, rapid serial naming (Aravena et al., 2017), insufficient vocabulary knowledge (Peterson & Pennington, 2012; Snowling, 2012), and the struggle to use metacognitive knowledge effectively (Mastrothanasis et al., 2018). Metacognition refers to understanding (knowledge) and controlling cognitive activities (strategies) and processes during learning. The metacognitive perspective to reading difficulties emphasises the importance of metacognitive knowledge in reading comprehension. While children with reading difficulties can possess this knowledge, in general, they use metacognitive strategies less frequently than their typically developing peers (Mastrothanasis et al., 2018). In addition, it is increasingly accepted that dyslexia may have different aetiologies (Werth, 2018).

Although children diagnosed with dyslexia may improve phonological, reading and writing skills when different strategies are learned (Werth, 2018), being unable to read and write fluently remains an obstacle in education, as it affects children's well-being and school results (Dahlin, 2010). Therefore, careful assessment procedures for classifying dyslexia are essential. Dyslexia, unfortunately, cannot be diagnosed before formal literacy instruction starts (Peterson & Pennington, 2012). Furthermore, dyslexia might coincide with other developmental disabilities (Werth, 2018) but is unrelated to intelligence, as it seems to occur across the full intelligence range (Elliott & Resing, 2015; Snowling et al., 2020).

The relationship between intelligence and reading and writing skills

Typically, intelligence is measured through static tests, which evaluate cognitive skills like fluid intelligence, verbal short-term memory, auditory short-term memory, long-term memory, verbal skills and processing speed, considered first-order domain-specific intelligence factors (Schneider & McGrew, 2018), all crucial for literacy development (Zarić et al., 2020). For example, fluid intelligence plays a significant role in learning to read (Peng et al., 2019), while in older children, it becomes more tied to reading comprehension, the ultimate goal of reading instruction (Motallebzadeh & Tabatabaee Yazdi, 2016). Children diagnosed with dyslexia may not be able to show their full potential in a static intelligence test (Giofrè & Cornoldi, 2015), as they tend to score lower on some first-order domain-specific factors in intelligence tests like auditory short-term memory (Ruiter et al., 2020), processing speed (Werth, 2018) and auditory information processing (Berninger & Richards, 2010). Therefore, the usability of static intelligence tests in dyslexia assessments is being questioned, and the classification of dyslexia should be made regardless of intelligence (Werth, 2018).

Aims of the current study

The current study aimed to investigate the potential effects of training on dynamic reading and writing tests in typically developing children and children diagnosed with dyslexia. We aimed to analyse the potential relationships between the dynamic reading and writing test and more conventional reading and spelling tests used in the Netherlands for assessment purposes. Furthermore, we aimed to investigate whether children's accuracy scores on the dynamic test, before and after training, would be related to intelligence.

The first research question concerned the potential effect of training on reading and writing skills and focused on children's progression from the pre-test to the post-test. Based on previous research (Aravena et al., 2017; Dixon et al., 2022; Mata & Serrano, 2019; Navarro & Lara, 2017), it was hypothesised that children in the experimental condition who received training between pre-test and post-test would show more improvement in correct answers on the Phonemic Awareness, Prosodic Awareness, Writing Competence, and Context-Dependent Words subtests than children in the control condition who did not receive training. In addition, it was hypothesised explicitly that typically developing children would show more improvement than those with dyslexia, irrespective of whether they were trained. Research shows that children diagnosed with dyslexia experience difficulties performing on static and dynamic reading and writing tests (Aravena et al., 2017; Snowling et al., 2020) and have a lack of sensitivity to extra instruction or treatment (Aravena et al., 2017; Mata & Serrano, 2019).

The second research question concerned the relationship between the pre-test and post-test scores of the dynamic reading and writing test, Phonemic Awareness, Prosodic Awareness, Writing Competence and Context-Dependent Words on the one hand and conventional (pseudo) word reading, phonological awareness and spelling tests on the other hand. Children's pre-test accuracy scores considered static measures, were expected to correlate positively with static Word Reading Fluency, Pseudoword Reading, and Phonological Awareness accuracy scores. In contrast, children's pre-test accuracy scores on Writing Competence and Context-Dependent Words were expected to correlate positively with the Spelling pre-test accuracy scores (Navarro & Lara, 2017). Moreover, it was hypothesised that this positive relationship between subtests would be found in both typically developing children and children with dyslexia. Regarding children's accuracy scores at the post-test, it was expected that the accuracy scores of those in the control condition, which are also considered static measures, would also correlate with the conventional measures. However, the post-test accuracy scores of those in the experimental condition considered dynamic measures would not (Mata & Serrano, 2019).

The final research question considered the potential relationship between static and dynamic reading and writing scores and intelligence. Intelligence was expected to correlate positively with pre-test static accuracy scores (Calero et al., 2011; Mata & Serrano, 2019). Concerning children's post-test accuracy scores on the dynamic reading and writing test, it was hypothesised that intelligence would also correlate to the static accuracy scores of untrained children in the control condition. Furthermore, considering the compensatory nature of dynamic testing, as the potential for learning does not always align with intelligence, no correlations were anticipated for the dynamic post-test measures of the trained children in the experimental condition (Bosma & Resing, 2006). Concerning the potential differences between the typically developing children and those diagnosed with dyslexia, no differences in both conditions were expected as dyslexia occurs across the entire intelligence range (Elliott & Resing, 2015; Snowling et al., 2020).

Method

Participants

Finally, eighty children between the ages of seven and nine and a half participated in the current study, of whom 41 were girls and 39 were boys (M Age = 8.4 years, SD = 0.07). Children were categorized into two groups: typically developing and diagnosed with dyslexia. Those diagnosed with dyslexia were formally identified based on the definition used in the Dutch Protocol for Dyslexia Diagnostics and Intervention (Tijms et al., 2021)and represented the 10% with the weakest reading or writing abilities. The remaining children were assigned to the typically developing children group. Prior to this, eleven children were excluded, as they were not formally diagnosed with dyslexia but demonstrated reading scores that fell within the 10% weakest range. Furthermore, seven children were excluded due to dropping out. The typically developing children (n = 39) were recruited from regular primary mainstream schools in Zuid-Holland. The children diagnosed with dyslexia (n = 41) were recruited from 1801, an educational service in the West of the Netherlands. The total distribution of children diagnosed with dyslexia and typically developing children over the two conditions is displayed in Table 1. Furthermore, all children with dyslexia received clinical dyslexia intervention at the time of this study. Children were randomly allocated to the experimental or control condition as the result of a blocking procedure based on gender and intelligence.

Measures

Intelligence Screener subtest of Intelligence and Development Scales for Children-2 (Grob & Hagmann-von Arx, 2018). The IDS-2 intelligence screener estimates children's intelligence. Administration of this test takes about 15 minutes. The screener consists of two subtests: Category Naming, a verbal test of crystallised intelligence, and Matrix Reasoning, a non-verbal measure of fluid intelligence. The subtest Category Naming consists of 34 multiple-choice items (first pictures, later words) referring to children's verbal reasoning and prior knowledge of categories. The diagnostician showed three categorized entities' pictures (and later says the name). The child is asked to name the type in which the three entities fit. Category naming has a test-retest reliability of r =. 93, and the correlation with general intelligence is r =. 64 (Grob & Hagmann-von Arx, 2018). The subtest Matrix Reasoning consists of 35 multiple-choice items referring to children's inductive reasoning and problem-solving skills. Children were asked to choose one of five possible solutions that fit best in an analogy of type A:B:C:? Matrix Reasoning has a test-retest reliability of r = .86. The correlation with general intelligence is r = .65 (Grob & Hagmann-von Arx, 2018).

Phonological Awareness Subtest of the Clinical Evaluation of Language Fundamentals CELF-4NL (Kort et al., 2005). The phonological awareness subtest measures the ability to rhyme and manipulate sounds. In approximately 15 minutes, it aims to gain insight into the child's knowledge of the sound structure of Dutch and their ability to deal with speech sounds in various exercises. These exercises concern the representation of sentences, syllables and phonemes, the combination of syllables and phonemes, the indication of syllables in a word and the identification and processing of phonemes. These skills are required for learning to read and write. The phonological awareness test has a test-retest reliability of r = .80 (Kort et al., 2005).

Spelling [Dyslexia Screenings Test DST-NL] (Kort et al., 2005). The Spelling subtest measures the child's writing ability. The child had to write as many dictated Dutch words as possible in two minutes. The words listed by the tester have increasing difficulty, with a maximum of 36 words. The Spelling test has a test-retest reliability of r = .95 (Kort et al., 2005).

Word Reading Fluency [Brus One-Minute-Test test form A] (Brus et al., 2019). The Brus One-Minute-Test measures isolated Word Reading Fluency reading skills. The One-Minute-Test is a word recognition test. The child was given a piece of paper with 116 words of increasing difficulty. The words were arranged in four columns of equal length and presented in Universe typeface, font size 18. The child is asked to read as many words as correctly as possible in one minute. The One-Minute test has a test-retest reliability of r =. 96 (Brus et al., 2019).

Pseudoword Reading [Klepel-R1 min form A] (Van den Bos et al., 2019). The Klepel-R1 min measures decoding skills. Alphabetical knowledge must be deployed to integrate the voiced letters into a word. The child was given a piece of paper with 116 pseudowords of increasing difficulty. The words were arranged in four columns of equal length and presented in Universe typeface, font size 18. The child was asked to read as many words as possible in one minute. The Klepel-R1min has a test-retest reliability of r = .91 for seven and eight-year-olds and an r = .97 for nine and ten-year-old children (Van den Bos et al., 2019).

The dynamic reading and writing test (Mata & Serrano, 2019) assesses the potential for learning reading and writing skills and improving skills relevant to developing this expertise. The test was converted and cross-translated from Spanish into Dutch. The four subtests of the dynamic reading and writing test measure phonemic awareness, prosodic awareness, knowledge of writing rules and the spelling of homophonic words, all considered basic essential reading and writing skills (Mata & Serrano, 2019). The test takes 60 to 80 minutes, with 15 to 20 minutes for each subtest. Each subtest consisted of a pre-test in which the child solved tasks independently.

Design and Procedure

Parental and school consent for participation was obtained in writing before the study began. The study was also approved by the Committee of Ethics in Psychology (CEP) at the corresponding author's institution. This study had an experimental pre-test-training-post-test design with two conditions: an experimental and a control condition, as seen in Table 1.

Table 1. Schematic overview of the design of the study

Condition	Group	Session 1: 30 minutes	Session 2: 60-75 minutes			
		Preliminary Assessment[1]	The dynamic test of reading and writing:			
			Pre-test	Training	Post-test	Training
Control condition (*n* = 37)	Children diagnosed with dyslexia (*n* = 20)	X	X	-	X	X
	Typically developing children (*n* = 17)	X	X	-	X	X
Experimental condition (*n* = 43)	Children diagnosed with dyslexia (*n* = 21)	X	X	X	X	-
	Typically developing children (*n* = 22)	X	X	X	X	-

Note 1. The following instruments were used as a preliminary investigation: IDS-2 Intelligence and Development Scales for Children: Intelligence Screener, Word Reading Fluency: [Brus], Pseudoword Reading [Klepel], Dyslexia Screenings Test: subtest Two-Minutes Writing, and Clinical Evaluation of Language Fundamentals: subtest Phonological Awareness.

Training

Next, a standardized and hierarchical training phase is included, commencing with hints at an abstract level and progressing to the task-specific level for hints in each subtest. Each child received all available hints. The training phase reflected performance, retelling the task, and various exercises with visually supported materials. See Table 2 for more information on the training principles. During the post-test, the child independently completed the pre-test again. Two scores were obtained per subtest. The first is the pre-test score, which measures current knowledge of the required skill in the zone of actual development. This was considered a static test score. Secondly, a post-test score obtained after training reflecting the zone of proximal development is considered a dynamic test score.

Subtest 1: Phonemic Awareness: The phonemic awareness subtest measures children's ability to construct words by identifying smaller units (phonemes). The examiner covered her mouth with her hands while sounding out fourteen words, after which the child was tasked with identifying the spoken word. Mata and Serrano (2019) found an internal consistency of this subtest of α =.89.

Subtest 2: Prosodic Awareness: The subtest prosodic awareness evaluates whether children know the emphasis in a word. Eighteen audio-recorded words were played to the child, who had to determine which sound group contained the primary stress. Mata and Serrano (2019) found an internal consistency of this subtest of α = .87.

Subtest 3: Writing Competence: This subtest evaluates the ability to correctly write words and use phonological and writing rules in words and sentences. Twenty-five words were dictated to the child. Every word was said twice. Mata and Serrano (2019) found an internal consistency of this subtest of α = .83.

Subtest 4: Context-Dependent Words: This subtest measures the child's ability to determine the correct form of a homophonic word in the context of a sentence. Eighteen sentences containing a missing homophone were presented. The correct answer had to be selected from three words, two homophones and a word slightly similar to these homophones. Mata and Serrano (2019) found an internal consistency of this subtest of α = .62.

Table 2. Overview of the dynamic reading and writing test (based on Mata & Serrano, 2019)

Subtest	Task	Training			
		Hint 1	Hint 2	Hint 3	Hint 4
Phonemic Awareness	Make a word out of phonemes	Discussion and sentence-making with cards	Marking the phonemes on a card	Making (nonsense) words by throwing dice with syllables	Making words by rolling dice with vowels and consonants
Prosodic Awareness	Point out the syllable with an emphasis on nonsense words	Tapping the table, pointing out the loudest tap	Clapping words, thereby counting syllables	Pointing out the loudest syllable on a card	Practising with cards
Writing Competence	Write dictated words	Discussion of rules and working with cards, circling the same letter clusters	Completing words	Completing verbs	Practising with sentences
Context-dependent words (homophones)	Write the correct missing homophonic word in a sentence	Training the memory by seeing pictures matching with the homophones. In six steps, a part of these pictures is taken away, finally leading to a picture of the two letters associated with the homophone.			

Data Analyses

Before answering the research questions, a one-way MANOVA was conducted. The dependent variables in this analysis included age, intelligence, Technical Reading, Pseudoword Reading, Spelling and Phonological Awareness. Furthermore, the pre-test accuracy scores of the four dynamic reading and writing subtests were included. The independent variables were Condition (experimental versus control condition) and subgroup (typically developing children versus children diagnosed with dyslexia). Test-retest reliability of all reading and writing subtests was calculated by performing Pearson correlations separately for the experimental and control conditions. A Repeated Measures of Multivariate Analysis of Variance (RM MANOVA) was used to address the first research question. Session (pre-test versus post-test) was included as a within-subjects factor, condition (experimental versus control) and subgroup (typically developing versus diagnosed with dyslexia) as between-subjects factors. In addition, the dependent variables were the dynamic reading and writing subtests of Phonemic Awareness, Prosodic Awareness, Writing Competence, and Context-Dependent Words. To respond to the second and third research questions, Pearson product-moment correlations were conducted between pre-and post-test reading and writing performance measures of typically developing children and children diagnosed with dyslexia on the one hand and conventional reading and writing measures and intelligence on the other hand. In these analyses, the results of the children diagnosed with dyslexia and typically developing children were analyzed individually. Additionally, the assumptions of normality and homogeneity were verified for all dependent variables.

Results

Before conducting our analyses, assumptions for normality for typically developing children and children diagnosed with dyslexia were checked through the Shapiro-Wilk test. The findings of the Shapiro-Wilks' test indicated that in the typically developing children, assumptions for normality were met for intelligence D (39) = .965, p >.05, Word Reading Fluency D (39) = .977, p >.05, Pseudoword Reading D (39) = .961, p >.05, and Spelling D (39) = .973, p >.05. In the children diagnosed with dyslexia assumptions for normality were met for intelligence D (41) = .973, p >.05, Word Reading Fluency D (41) = .987, p >.05 and Prosodic Awareness D (41) = .962, p >.05. Furthermore, assumptions for homogeneity typically developing children and children diagnosed with dyslexia were checked through Levene's test. The assumptions for homogeneity check indicated that assumptions were met for intelligence F (1,78)= .063, p >.05, age IQ F (1,78)=.024, p >.05, Word Reading Fluency F (1,78)=2.22, p >.05, Pseudoword Reading F (1,78)=3.34, p >.0), Spelling F (1,78)= .618, p >.05, Phonological Awareness F (1,78)= .035, p >.05, Phonemic Awareness F (1,78)= 1.900, p >.05, Prosodic Awareness F (1,78)= .338, p >.05, Writing Competence F (1,78)=3.838 , p >.05 and Context-Dependent Words F (1,79)= .959, p >.05.

Initial group comparisons

An analysis of the multivariate effects revealed no significant differences in these variables between the children in the experimental and control condition (Wilks' λ = .91, F (10,67) = .64, p = .774, η_p^2 = .09). The multivariate subgroup effect was, however, significant, Wilks' λ = .33, F (10,67) = 13.70, p < .001, η_p^2 = .67). The univariate between-subjects subgroup effects, in combination with a visual examination of the mean scores, revealed that children diagnosed with dyslexia were, on average, older (F(1,76) = 13.30, p <. 001, η_p^2 = .149) and had lower accuracy scores on word reading fluency (F(1,76) = 54.42, p < .001, η_p^2 = . 417), prosodic awareness (F(1,76) = 7.88, p = .006, η_p^2 = . 094), and pseudoword reading (F(1,76) = 87.78, p <.001, η_p^2 = . 536). No differences were found on intelligence (F(1,76) = 0.091, p = .763 , η_p^2 = . 002), phonological awareness (F(1,76) = .554, p = .459 , η_p^2 = . 007), spelling (F(1,76) = .846 , p = .361 , η_p^2 = . 011), phonemic awareness (F(1,76) = .042, p = .839 , η_p^2 = .001), context-dependent words (F(1,76) = .027, p = .869 , η_p^2 = .000) and writing competence (F(1,76) = 1,34, p <.716, η_p^2 = . 002). Means and standard deviations can be found in Table 3. Furthermore, a Chi-square analysis was conducted to explore the distribution of girls and boys between the two subgroups and conditions. Chi-square analysis unfolded a similar distribution of boys and girls across subgroups (χ^2(1) = 1.82, p = .18) as well as conditions (χ^2(1) < .001, p = .99).

Table 3. Means and standard deviations on age, preliminary assessment tests and dynamic reading and writing pre-test accuracy scores divided by subgroup and condition

Variable		Control Condition (n=37)	Experimental Condition (n=43)	Typically developing (n=39)	Diagnosed with dyslexia (n=41)	Total (n=80)
Age in months	*M*	101.22	101.88	97.82	105.15	101.57
	SD	8.56	10.49	8.71	9.11	9.59
Intelligence	*M*	92.68	93.67	93.64	92.80	93.21
	SD	11.34	10.50	10.87	10.93	10.84
Word Reading Fluency	*M*	40.46	41.56	51.05	31.54	41.05
	SD	16.87	14.16	23.43	10.28	15.38
Pseudoword Reading	*M*	21.95	24.12	31.00	15.61	23.11
	SD	10.86	10.36	8.41	5.97	10.58

Spelling	*M*	11.16	11.12	11.69	10.61	11.14
	SD	2.39	4.69	4.88	5.36	5.13
Phonological Awareness	*M*	40.46	39.70	40.26	39.85	40.05
	SD	2.91	3.04	3.18	2.82	3.00
Phonemic Awareness	*M*	11.62	11.81	11.77	11.68	11.72
	SD	2.39	1.86	2.38	1.84	2.11
Prosodic Awareness	*M*	6.89	7.67	5.90	8.66	7.31
	SD	5.33	4.97	4.83	5.07	5.12
Writing Competence	*M*	13.89	14.58	14.38	14.15	14.26
	SD	5.72	5.70	6.31	5.09	5.68
Context-Dependent Words	*M*	11.95	11.35	11.72	11.54	11.63
	SD	4.52	4.68	4.89	4.34	4.58

Psychometric properties of the dynamic reading and writing test

Positive, high correlations between pre-test and post-test accuracy scores were found in the control condition for Phonemic Awareness ($r(37) = .92$, $p < .001$); Prosodic Awareness ($r(37) = .79$, $p < .001$), Writing Competence ($r(37) = .95$, $p < .001$ and Context-Dependent Words ($r(37) = .63$, $p < .001$), indicating sufficient test-retest reliability. In the experimental condition, high positive correlations between pre-test and post-test accuracy scores were again found for all subtests (Phonemic Awareness: $r(43) = .61$, $p < .001$); Prosodic Awareness: $r(43) = .53$, $p < .001$; Writing Competence $r(43) = .91$, $p < .001$). A moderate correlation was found for the subtest Context-Dependent Words: $r(43) = .43$, $p = .004$). Overall, these findings indicate sufficient test-retest reliability. Fisher's *r*-to-*z* transformations unfolded significant differences for the subtests Phonemic Awareness ($z = -3.77$, $p < .001$), Prosodic Awareness ($z = -2.06$, $p = .02$), a first potential manifestation of training effectiveness. However, no significant differences were found for the subtest Writing Competence ($z = -1.30$, $p = .10$) and Context-Dependent Words ($z = -1.21$, $p = .11$). Cronbach's alpha coefficients were computed for the pre-test scores to analyse the internal consistency of the subtests. They demonstrated coefficients ranging from $\alpha = .63$ for the subtest Phonemic Awareness, $\alpha = .81$ for the subtest Context-Dependent words, $\alpha = .89$ for the subtest Writing Competence and finally $\alpha = .90$ for the subtest Prosodic Awareness.

Table 4. *Multivariate, univariate and between-subject effects RM MANOVA outcomes*

Between-subject effects	Wilk's λ	*F*	*p*	η_p^2
Multivariate within-subjects effects				
Session	.75	6.05	< .001	.25
Session x condition	.88	2.54	.047	.12
Session x subgroup	.98	.308	.872	.02
Session x condition x subgroup	.87	2.77	.034	.13
Univariate within-subjects effects				
Phonemic Awareness				
Session		19.53	< .001	.20
Session x condition		1.18	.280	.02
Session x subgroup		.61	.436	.01
Session x condition x subgroup		.26	.610	.003
Prosodic Awareness				
Session		2.14	.148	.03
Session x condition		9.43	.003	.11
Session x subgroup		.20	.665	.003
Session x condition x subgroup		1.64	.204	.02
Writing Competence				
Session		1.33	.253	.02

Session x condition		.07	.786	.001
Session x subgroup		.53	.471	.01
Session x condition x subgroup		4.62	.035	.06
Context-Dependent Words				
Session		5.70	.019	.07
Session x condition		2.02	.159	.03
Session x subgroup		.02	.880	.000
Session x condition x subgroup		2.35	.129	.03
Multivariate between-subjects effects				
Condition	.92	1.55	.198	.08
Subgroup	.88	2.40	.058	.12
Condition x subgroup	.75	6.00	<.001	.25
Univariate between-subjects effects				
Phonemic awareness				
Condition		.64	.426	.01
Subgroup		.25	.616	.003
Condition x subgroup		.22	.638	.003
Prosodic awareness				
Condition		6.35	.014	.08
Subgroup		8.08	.006	.10
Condition x subgroup		4.71	.033	.06
Writing Competence				
Condition		.27	.604	.004
Subgroup		.27	.606	.004
Condition x subgroup		9.40	.003	.11
Context-Dependent Words				
Condition		.02	.904	.000
Subgroup		.01	.910	.000
Condition x subgroup		2.09	.152	.03

Significance $p< .05$, $p< .01$

Effect of training

The effect of training on reading and writing accuracy scores was examined through Repeated Measures of Multivariate Analysis of Variance (RM MANOVA). All multivariate, univariate, within- and between-subject effects are displayed in Table 4. The multivariate within-subjects results indicated significant session ($p < .001$, $\eta_p^2 = .25$) and session x condition effects ($p = .047$, $\eta_p^2 = .12$). These findings, combined with a visual examination of the mean scores, as can be seen in Figure 1 and Table 5, indicated that all children's accuracy scores improved from pre- to post-test. Furthermore, the significant session x condition effect indicated a significant difference in the two conditions' level of improvement. In addition, an insignificant session x subgroup effect ($p = .872$, $\eta_p^2 = .02$) revealed that typically developing children and children diagnosed with dyslexia demonstrated equal levels of improvement from the pre-test to the post-test. An analysis of the multivariate between-subject effects revealed no significant condition ($p = .198$, $\eta_p^2=.08$) or subgroup ($p = .058$, $\eta_p^2=.12$) effects, indicating no differences at the condition or subgroup level. Univariate subgroup effects are described below.

Phonemic Awareness: The univariate effects unfolded a significant session effect ($p< .001$, $\eta_p^2 = .20$), but no significant effect of session x condition ($p = .280$, $\eta_p^2 = .02$), session x subgroup ($p = .436$, $\eta_p^2 = .008$), or session x condition x subgroup ($p = .610$, $\eta_p^2 = .003$). These results indicated that all groups of children performed better on this subtest from the pre-test to the post-test. In contrast to our hypothesis, we observed no significant differences between the experimental and control conditions. Also, opposite to our hypothesis, no significant differences in accuracy scores were found between typically developing children and children diagnosed with dyslexia. In addition, the between-subjects effects for the subgroup were insignificant (Phonemic Awareness, $p =. 616$, $\eta_p^2 = .003$). This finding demonstrated that typically developing children did not outperform their peers diagnosed with dyslexia.

Prosodic Awareness: The univariate effects unfolded no significant effect of session($p = .148$, $\eta_p^2 = .03$), but a significant session x condition effect ($p < .003$, $\eta_p^2 = .11$). Furthermore, no significant session x subgroup ($p = .665$, $\eta_p^2 = .003$) or session x condition x subgroup ($p = .204$, $\eta_p^2 = .02$) were unfolded. These results indicated that not all children performed better on this subtest from the pre-test to the post-test. Consistent with our hypothesis, children in the experimental condition showed a significantly higher increase in accuracy scores from pre-test to post-test than children in the control condition. Children in the control condition showed decreased accuracy scores from pre- to post-test. Contrary to our hypothesis, we did not observe any significant differences in the effects of training from pre-tests to post-tests between typically developing children and children diagnosed with dyslexia. In addition, a significant between-subjects effect for the subgroup (Prosodic Awareness, p = . 006, $\eta_p^2 = .10$) indicated, in combination with a visual check of the mean scores, that the typically developing children had higher scores than the children diagnosed with dyslexia.

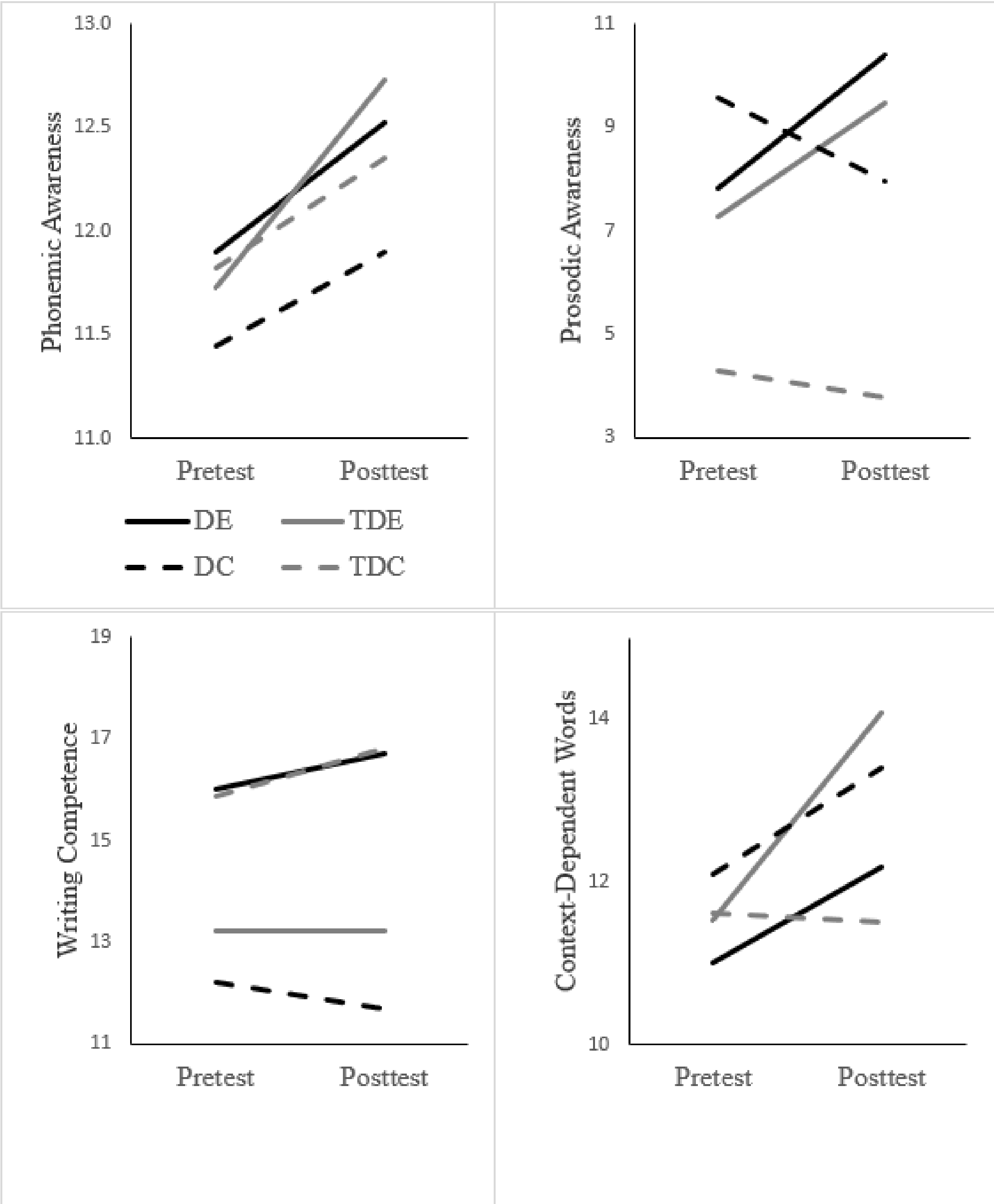
Writing Competence: The univariate effects unfolded no significant session(p = .253. ηp2 = .02), session x condition (p = .786, ηp2 = .001), session x subgroup ($p = .471$, $\eta_p^2 = .01$). However, a significant session x condition x subgroup ($p = .035$, $\eta_p^2 = .06$) was found. Contrary to the hypothesis, no significant improvements were observed from the pre-test to the post-test, and no differences were found between experimental and control conditions. However, significant differences in improvement levels from pre-test to post-test were found as a result of training and repeated practice between children diagnosed with dyslexia and typically developing children. Moreover, typically developing children did not outperform peers diagnosed with dyslexia, as indicated by the non-significant between-subjects effect for the subgroup (Writing Competence, p =. 606, $\eta_p^2 = .004$).

Context-Dependent Words: The univariate effects unfolded a significant session effect ($p = .019$, $\eta_p^2 = .07$), but no significant effect of session x condition ($p = .159$, $\eta_p^2 = .03$), session x subgroup ($p = .880$, η_p^2 =<.000), or session x condition x subgroup ($p = .129$, $\eta_p^2 = .03$) effects. These results indicated that all groups of children performed better on this subtest from the pre-test to the post-test. Contrary to the hypothesis, there was no significant improvement from pre-test to post-test, no significant differences between experimental and control conditions, and no significant differences in accuracy scores between children with dyslexia and typically developing children. Typically developing children did not outperform peers with dyslexia, as indicated by the non-significant between-subjects effect for the subgroup (Context-Dependent Words, p =. 910, η_p^2 <. 001).

Table 5. Basic statistics for accuracy scores on the dynamic reading and writing subtests at pre-and post-test

		Experimental Condition		Control Condition	
Group	M (SD)	Pre-test	Post-test	Pre-test	Post-test
Typically developing children					
Phonemic Awareness	*M (SD)*	11.73 (1.83)	12.73 (1.55)	11.82 (3.01)	12.35 (2.37)
Prosodic Awareness	*M (SD)*	7.55 (4.86)	9.32 (5.15)	3.76 (3.99)	3.82 (3.49)
Writing Competence	*M (SD)*	13.23 (5.74)	13.23 (5.86)	15.88 (6.86)	16.82 (7.14)
Context-Dependent Words	*M (SD)*	11.68 (4.99)	14.23 (3.68)	11.76 (4.88)	11.41 (5.01)
Children diagnosed with dyslexia					
Phonemic Awareness	*M (SD)*	11.90 (1.92)	12.52 (1.66)	11.45 (1.76)	11.90 (1.80)
Prosodic Awareness	*M (SD)*	7.81 (5.19)	10.38 (4.99)	9.55 (4.92)	7.95 (5.79)
Writing Competence	*M (SD)*	16.00 (5.42)	16.71 (5.66)	12.20 (3.98)	11.70 (3.44)
Context-Dependent Words	*M (SD)*	11.00 (4.42)	12.19 (4.63)	12.10 (4.30)	13.40 (3.63)

Figure 1. Mean accuracy scores of dynamic reading and writing subtests



Note. DE= children diagnosed with dyslexia in the experimental condition; DC= children diagnosed with dyslexia in the control condition; TDE= typically developing children in the experimental condition; and TDC= typically developing children in the control condition.

The relationship between static and dynamic reading and writing performance, conventional reading and spelling performance

The second research question was investigated through Pearson product-moment correlations. Pre-test scores of all children and post-test reading and writing scores of the untrained children were considered static measures In addition, the post-test scores of the trained children were considered dynamic measures (see Table 6).

Firstly, looking at pre-test scores, correlations were found in the anticipated direction: Phonemic Awareness and Prosodic Awareness accuracy scores correlated positively with conventional reading scores, and Writing Competence and Context-Dependent word accuracy scores correlated positively with the Spelling test in typically developing children and children diagnosed with dyslexia. In addition, unexpectedly, the subtests Writing Competence and Context-Dependent Words also correlated moderately to strongly with conventional reading tests. This pattern was also observed, though to a lesser degree, in children diagnosed with dyslexia. These findings suggest that the dynamic writing subtests might involve abilities similar to those needed in conventional reading tests.

Secondly, the post-test accuracy scores of the children in the control condition revealed strong positive correlations between Writing Competence and Context-Dependent Words on the one hand and Word Reading Fluency and Spelling on the other hand. These findings supported our hypothesis that the reading post-test accuracy scores of the untrained children correlated with conventional post-test reading scores, and the writing test scores correlated with spelling scores in both typically developing children as children diagnosed with dyslexia. Again, unexpectedly, the subtest Writing Competence and Context-Dependent Words also correlated moderately to strongly with the scores of the conventional reading tests.

In addition, the post-test accuracy scores of the trained children revealed correlations with conventional reading and spelling subtests. Moderate to strong correlations were found between the subtest Writing Competence and Context-Dependent Words on the one hand and Word Reading Fluency, Pseudoword Reading and Spelling on the other. However, these correlations were generally stronger than the post-test measures of the untrained children in typically developing children and children diagnosed with dyslexia.

Table 6. Pearson Product-Moment correlation matrix between dynamic reading and writing measures (divided by subgroup and condition) and conventional static test measures

Group	Pre-test				Post-test experimental condition				Post-test control condition			
	Phonemic Awareness	Prosodic Awareness	Writing Competence	Context-Dependent Words	Phonemic Awareness	Prosodic Awareness	Writing Competence	Context-Dependent Words	Phonemic Awareness	Prosodic Awareness	Writing Competence	Context-Dependent Words
Typically developing children												
Word Reading Fluency	.17	.26	.63**	.23	.12	.42	.69**	.02	.28	.03	.67**	.43
Pseudoword Reading	-.12	.26	.32*	.10	-.15	-.07	.49*	-.05	-.03	.14	.28	.28
Spelling	.50**	.24	.75**	.38*	.51*	.28	.55**	.30	.58*	.08	.84**	.66**
Phonological Awareness	.25	.00	.53**	.05	.39	.17	.57**	.10	.17	-.16	.36	.02
Intelligence	.21	.17	.18	.16	.64**	.20	.29	.15	.33	-.16	-.04	.11
Children diagnosed with dyslexia												
Word Reading Fluency	.12	-.06	.56**	.31	-.37	-.25	.53*	.10	.03	.14	.50*	.34
Pseudoword Reading	-.18	-.29	.31	-.03	-.65**	-.33	.14	-.15	-.21	-.05	.38	.13
Spelling	.12	.002	.34*	.01	.13	-.39	.35	-.16	-.12	.13	.52*	.24
Phonological Awareness	.06	.24	.34*	.05	.19	.07	.39	.29	-.11	.55*	.52*	.22
Intelligence	.34*	.13	.05	.05	.52*	.28	.04	-.02	.37	.11	.16	-.18

Significance * *p*< .05, ** *p*< .01

The relationship between dynamic reading and writing pre-test and post-test accuracy and intelligence

The third research question was investigated through Pearson product-moment correlations. As mentioned above, all children's pre-test scores and the untrained children's post-test scores were considered static scores, and the trained children's post-test scores were considered dynamic scores. Results are shown in Table 6. At pre-test, the results revealed modest correlations between intelligence and the subtests of Phonemic Awareness, Prosodic Awareness, Writing Competence and Context-Dependent Words for the typically developing children. However, a significant moderate correlation was observed between intelligence and Phonemic Awareness in children diagnosed with dyslexia, supporting the expected relationship between the subtest and intelligence. Next, at the post-test, the accuracy scores of the untrained children revealed, as expected, generally moderate to small positive correlations between intelligence and Phonemic Awareness, Prosodic Awareness, Writing Competence and Context-Dependent Words in typically developing children and children diagnosed with dyslexia. In contrast, post-test scores of the children in the experimental condition unexpectedly revealed robust, significant correlations between Phonemic Awareness and intelligence in both typically developing children and children diagnosed with dyslexia. Unlike our hypothesis, dynamic measures generally revealed stronger correlations with intelligence than static measures.

Discussion

The current study investigated whether a dynamic reading and writing test would offer information on the potential for learning reading and writing for primary school typically developing children and children diagnosed with dyslexia. Furthermore, we aimed to gain more insight into the relationship between dynamic reading and writing test accuracy scores and more conventional reading and spelling tests. In addition, we investigated the relationship between intelligence and accuracy scores on the dynamic and static reading and writing pre- and post-tests.

This study offers preliminary support for using a dynamic reading and writing test, as seen in Table 5 and Figure 1. The study revealed that short, standardised training in Phonemic Awareness, Prosodic Awareness, Writing Competence and Context-Dependent Words could improve accuracy scores of typically developing children and children diagnosed with dyslexia. However, only a significant level of improvement beyond the influence of practice from the pre-test to the post-test was found for the subtest Prosodic Awareness, suggesting that the hints and tasks used in the Prosodic Awareness training might have tapped into the zone of Proximal Development (Vygotsky, 1978). The hints likely helped children to bridge the gap between their current level of understanding and their potential level of understanding. Additionally, the tasks were challenging enough to improve accuracy scores with the appropriate support from a competent person. These findings align with Vygotsky's theory by demonstrating how scaffolding within the Zone of Proximal Development can improve the Prosodic Awareness of typically developing children and children diagnosed with dyslexia. Furthermore, the structure of the tasks and the progression from more abstract hints to more concrete ones may have contributed to improving metacognitive strategies, as children were encouraged to reflect on their skills and participate actively. Given the significance of metacognition and the difficulties that children diagnosed with dyslexia experience with metacognitive knowledge and strategies, this is an important finding (Mastrothanais et al., 2018). However, this finding needs further research. The absence of improvement beyond the influence of practice on the subtests Phonemic Awareness, Writing Competence and Context-Dependent Words prompted questions about the complexity of the test items and the content of the training of these subtests. No differences between typically developing children and children diagnosed with dyslexia in the extent to which they improved were found, a positive finding highlighting the potential advantages of integrating training in the testing procedure, especially for children diagnosed with dyslexia, considering that children diagnosed with dyslexia do not always respond to training (Aravena et al., 2017).

Dyslexia is often explained by the phonological deficit theory, which attributes reading and writing difficulties to deficits in phonological representations (Aravena et al., 2017; Melby-Lervåg et al., 2012; Peterson & Pennington, 2012; Snowling, 2012). In the current study, children diagnosed with dyslexia did appear to have deficiencies in phonological awareness. However, they performed better than their typically developing peers on one subset of phonological awareness: phonemic awareness than their typically developing peers. This finding can be partially attributed to the fact that the children had already received clinical dyslexia intervention before the study took place. In these interventions, the focus was primarily on phonemic awareness, the smallest units of sounds in language. Again, this finding needs further research. Furthermore, it should be noted that the group typically developing children includes children with no problems with reading and writing and children who experience minor reading and spelling problems, resulting in relatively large inter-individual variation within this group. The fact that the children who were not trained showed progression could be due to a practice effect, as research suggests that task performance develops when tested twice (Resing et al., 2019).

As observed in Table 6, the dynamic reading and writing test generally seemed to require skills similar to those required by the conventional tests, and both tests were based on the same concepts. We unexpectedly found that the dynamic writing pre-tests correlated with conventional reading tests, emphasising the complementary nature of reading and writing skills (Galuschka et al., 2020). This relationship was also, although to a lesser extent, observed in children with dyslexia. In addition, in contrast to the static pre-and post-test measures, the dynamic reading and writing post-test measures showed a strong association with conventional reading and writing tests and intelligence, as evidenced in Table 6. Training seemed to influence these associations. The specific language-based skills targeted in training might align closely with skills required in conventional reading and spelling tests and verbal intelligence tasks in typically developing children and children diagnosed with dyslexia. This is an interesting finding, given the importance of language development on reading development (Lyster et al., 2020). However, this explanation requires further research to comprehend the full impact of training.

Implications and Limitations

Dynamic testing principles revolve around the learning process and may better reflect children's abilities. Teachers, educational psychologists and dyslexia clinicians should apply dynamic testing principles. Dynamic tests may capture specific reading, spelling, and intelligence aspects more effectively than static measurements. These findings also advocate the importance of selecting appropriate tests in clinical practices and education. A few words of caution are needed when interpreting these results, as this study represents an initial exploration of combined dynamic testing of reading and writing in the Netherlands. Future studies might want to elaborate on and refine the test items and training content. They might also include three groups of children: Typically developing children, children diagnosed with dyslexia, and children with mild reading and writing problems to investigate potential differences between these groups in more detail. Moreover, future research should aim for larger sample sizes to obtain more statistical power and generalizability. To conclude, first and foremost, the dynamic reading and writing test can be an addition to assessment in education for typically developing children and those diagnosed with dyslexia, as it helps children demonstrate their potential for reading and writing. Consequently, by closely observing learning processes through collaboration with the child and offering explicit training, teachers and dyslexia clinicians can better understand an individual child’s educational needs. As shown in the current study, explicitly teaching writing skills also impacts the development of reading skills.

Compliance with Ethical Standards

Ethical Standards

All study procedures involving human participants followed institutional and/or national research committee ethical standards and the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This study has also been approved by the Psychology Research Ethics Committee Social and Behavioural Sciences Leiden University (ethics reference number: 2020-10-21-B. Vogelaar-V4-2634)

Author Contributions

Conceptualization, M.d.V.W.; methodology, B.V.; validation, B.V.; formal analysis, B.V. and M.d. V. W; resources, B.V.; data curation, B.V; writing-original draft preparation, M.d.V.W; writing-review and editing, B.V., S.M, F.S., J.V. and M.d.V.W; visualisation, M.d.V.W; supervision B.V.; project administration, B. V.. All authors have read and agreed to the published version of the manuscript.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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Received: 29-01-2024
Accepted: 18-09-2024
Published Online: 10-02-2025

References

Aravena, S., Tijms, J., Snellings, P., & van der Molen, M. W. (2017). Predicting individual differences in reading and spelling skills with artificial script–based letter–speech sound training. *Journal of Learning Disabilities, 51*(6), 552–564. https://doi.org/10.1177/0022219417715407

Berninger, V., & Richards, T. (2010). Inter-relationships among behavioural markers, genes, brain and intervention in dyslexia and dysgraphia. *Future Neurology*, *5*(4), 597–617. https://doi.org/10.2217/fnl.10.22

Bosma, T., & Resing, W. C. M. (2006). Dynamic assessment and a reversal task: a contribution to needs-based assessment. *Educational and Child Psychology*, *23*(3), 81–98. https://doi.org/10.53841/bpsecp.2006.23.3.81

Bridges, M., & Catts, H. W. (2011). The use of a dynamic screening of phonological awareness to predict risk for reading disabilities in kindergarten children. *Journal of Learning Disabilities*, *44*(4), 330–338. https://doi.org/10.1177/0022219411407863

Brus, B. Th. &Voeten, M.J.M. (2019). *Een-Minuut-Test vorm A en B. Verantwoording en Handleiding* (2[e]druk)[*One Minute Test, form A and B, manual and justification*]. Berkhout testmateriaal. Harcourt Test Publishers.

Calero, M. D., Belen, G. M. M., & Robles, M. A. (2011). Learning potential in high Intelligence children: The contribution of dynamic assessment to the identification of gifted children. *Learning and Individual Differences, 21*(2), 176–181.https://doi.org/10.1016/j.lindif.2010.11.025

Cho, E., Compton, D. L., Fuchs, D., Fuchs, L. S., & Bouton, B. (2012). Examining the predictive validity of a dynamic assessment of decoding to forecast response to tier 2 Intervention. *Journal of Learning Disabilities*, *47*(5), 409–423. https://doi.org/10.1177/0022219412466703

Cho, E., Compton, D. L., & Josol, C. K. (2019). Dynamic assessment as a screening tool for early identification of reading disabilities: a latent change score approach. *Reading and Writing*, *33*(3), 719–739. https://doi.org/10.1007/s11145-019-09984-1

Dahlin, K. I. E. (2010). Effects of working memory training on reading in children with special needs. *Reading and Writing*, *24*(4), 479–491. https://doi.org/10.1007/s11145-010-9238-y

Dixon, C., Oxley, E., Nash, H. & Gellert, A. S. (2022). Does dynamic assessment offer an alternative approach to identifying reading disorder? A systematic review. *Journal of learning disabilities 1-* 17. https://doi:10.1177/00222194221117510.

Elliott, J., & Resing, W. (2015). Can intelligence testing inform educational intervention for children with reading disability? *Journal of Intelligence*,*3*(4), 137–157. https://doi.org/10.3390/jintelligence3040137

Fuchs, D., Compton, D. L., Fuchs, L. S., Bouton, B., & Caffrey, E. (2011). The construct and predictive validity of a dynamic assessment of young children learning to read: Implications for RTI frameworks. *Journal of Learning Disabilities*, *44*(4), 339–347. https://doi.org/10.1177/0022219411407864

Galuschka, K., Görgen, R., Kalmar, J., Haberstroh, S., Schmalz, X., & Schulte-Körne, G. (2020). Effectiveness of spelling interventions for learners with dyslexia: A meta-analysis and systematic review. *Educational Psychologist*, *55*(1), 1–20. https://doi.org/10.1080/00461520.2019.1659794

Gellert, A. S., & Elbro, C. (2017). Try a little bit of teaching: A dynamic assessment of word decoding as a kindergarten predictor of word reading difficulties at the end of grade 1. *Scientific Studies of Reading*, *21*(4), 277–291. https://doi.org/10.1080/10888438.2017.1287187

Giofrè, D., & Cornoldi, C. (2015). The structure of intelligence in children with specific learning disabilities is different as compared to typically development children. *Intelligence*, *52*, 36–43. https://doi.org/10.1016/j.intell.2015.07.002

Grob, A., Hagmann-von Arx, P. (2018). *IDS-2 Intelligentie en ontwikkelingschalen voor kinderen en jongeren [IDS-2 Intelligence and developmental scales for children and young people]*, Nederlandse bewerking door Ruit, S, Timmerman, M & Visser, L.

Kort, W., Bos, K.P. van den, Spelberg, H.C. Lutje, Wild, S. van der, Schittekatte, M.,Vermeir G. & Verhaeghe, P. (2005). *Dyslexie Screening Test, DST-Nl. Handleiding [Dyslexia screeningtest, DST-NL. Manual]*. Harcourt Test Publishers.

Lyon, G. R., Shaywitz, S. E., &Shaywitz, B. A. (2003). A definition of dyslexia. *Annals of Dyslexia*, *53*(1), 1–14. https://doi.org/10.1007/s11881-003-0001-9

Lyster, S. H., Snowling, M. J., Hulme, C., & Lervåg, A. (2020). Preschool phonological, morphological and semantic skills explain it all: following reading development through a 9-year period. *Journal of Research in Reading*, *44*(1), 175–188. https://doi.org/10.1111/1467-9817.12312

Mastrothanais, K., Kalianou, M., Katsifi, S., & Zouganali, A. (2018). The use of metacognitive knowledge and regulation strategies of students with and without special learning difficulties. *International Journal Of Special Education*, *33*(1), 184–200. http://files.eric.ed.gov/fulltext/EJ1184100.pdf

Mata, S., van Geert, P., & van der Aalsvoort, G. (2017). Scaffolding young children: The utility of mediation in a classification Test. *Electronic Journal of Research in Education Psychology*, *15*(42), 441–466. https://doi.org/10.25115/ejrep.42.16117

Mata, S., & Serrano, F. (2019). *EPALE: Test de evaluación del potencial de aprendizaje para la lecto-escritura [Assessment test of learning potential for reading and writing]*. Editorial Universidad de Granada

Melby-Lervåg, M., Lyster, S. A. H., & Hulme, C. (2012). Phonological skills and their role in learning to read: A meta-analytic review. *Psychological Bulletin*, *138*(2), 322–352. https://doi.org/10.1037/a0026744

Motallebzadeh, K., & Tabatabaee Yazdi, M. (2016). The relationship between EFL learners' reading comprehension ability and their fluid intelligence, crystallised intelligence, and processing speed. *Cogent Education*, *3*(1), 1228733. https://doi.org/10.1080/2331186x.2016.1228733

Navarro, J. J., & Lara, L. (2017). Dynamic assessment of reading difficulties: Predictive and incremental validity on attitude toward reading and the use of dialogue/participation strategies in classroom activities. *Frontiers in Psychology*, *8*. https://doi.org/10.3389/fpsyg.2017.00173

Navarro, J. J., & Mora, J. (2011). Analysis of the implementation of a dynamic assessment device of processes involved in reading with learning-disabled children. *Learning and Individual Differences*, *21*(2), 168–175. https://doi.org/10.1016/j.lindif.2010.11.008

Peng, P., Wang, T., Wang, C., & Lin, X. (2019). A meta-analysis on the relation between fluid intelligence and reading/mathematics: Effects of tasks, age, and social economics status. *Psychological Bulletin*, *145*(2), 189–236. https://doi.org/10.1037/bul0000182

Perfetti, C., & Hart, L. (2002). The lexical quality hypothesis. In L. Verhoeven, C. Elbro, & P. Reitsma (Eds.), *Precursors of functional literacy* (pp. 189–213). The Netherlands: John Benjamin.

Peterson, R. L. & Pennington, B. F. (2012). Developmental dyslexia. *Lancet*, 379, 19972007.

Petersen, D. B., Allen, M. M., & Spencer, T. D. (2014). Predicting reading difficulty in first grade using dynamic assessment of decoding in early Kindergarten. *Journal of Learning Disabilities*, *49*(2), 200–215. https://doi.org/10.1177/0022219414538518

Resing, C. M., Elliott, J. G., & Vogelaar, B. (2020). Assessing potential for learning in School children. *Oxford Research Encyclopedia of Education*.

Resing, W. C., Bakker, M., Elliott, J. G., & Vogelaar, B. (2019). Dynamic testing: Can a robot as tutor be of help in assessing children's potential for learning? *Journal of Computer Assisted Learning*, *35*(4), 540–554. https://doi.org/10.1111/jcal.12358

Resing, W. C. M., & Elliott, J. G. (2010). Dynamic testing with tangible electronics: Measuring children's change in strategy use with a series completion task. *British Journal of Educational Psychology*, *81*(4), 579–605. https://doi.org/10.1348/2044-8279.002006

Ruiter, S. A. J., Visser, L., & Timmerman, M. E. (2020). Integratieve diagnostiek met de Intelligence and Development Scales-2 (IDS-2). [Integrative diagnostics with the intelligence and developmental scales IDS-2] *Kind En Adolescent*, *41*(1), 4–30. https://doi.org/10.1007/s12453-019-00229-0

Schneider, W.J., & McGrew, K.S. (2018). The Cattell-horn-Carroll theory of cognitive abilities. In D. P. Flanagan, & E.M. McDonough (Eds.), *Contemporary intellectual assessment: Theories, tests and issues*(pp 73-163) New Haven, CT: Guilford.

Serrano, F., &Defior, S. (2008). Dyslexia speed difficulties in a transparent orthography. *Annals of Dyslexia*, *58*(1), 81–95. https://doi.org/10.1007/s11881-008-0013-6

Serrano, F. (2015). *Intervención logpédica en problemas de lectura y escritura.* Editorial Técnica Avicam.

Serrano, F., Sánchez, J. B., & Olmedo, M. G. (2016). Galexia; Evidience-based software for intervention in reading fluency and comprehension. *Inted proceedings*.https://doi.org/10.21125/inted.2016.1419

Snowling, M. J. (2012). Early identification and interventions for dyslexia: a contemporary view. *Journal of Research in Special Educational Needs*, *13*(1), 7–14. https://doi.org/10.1111/j.1471-3802.2012.01262.x

Snowling, M. J., Hulme, C., & Nation, K. (2020). Defining and understanding dyslexia: past, present and future. *Oxford Review of Education*, *46*(4), 501–513. https://doi.org/10.1080/03054985.2020.1765756

Stuebing, K. K., Fletcher, J. M., LeDoux, J. M., Lyon, G. R., Shaywitz, S. E., &Shaywitz, B. A. (2002). Validity of IQ-discrepancy classifications of reading disabilities: A meta-analysis. *American Educational Research Journal*, *39*(2), 469–518. https://doi.org/10.3102/00028312039002469

Tijms, J., De Bree, E.H., Bonte, M., De Jong, P.F., Loykens, E., Reij, R. (2021). *Protocol Dyslexie Diagnostiek en Behandeling- versie 3.0*. [Protocol for dyslexia diagnostics and intervention version 3.0] Nederlands kwaliteitsinstituut Dyslexie (NKD).

Tzuriel, D. (2011). Revealing the effects of cognitive education programmes through dynamic assessment. *Assessment in Education: Principles, Policy & Practice*, *18*(2), 113–131. https://doi.org/10.1080/0969594x.2011.567110

Van den Bos, K.P. , Lutje Spelberg, H.C., Scheepstra, A.J.M. & Vries, J.R. de. (2019 *De Klepel. Vorm A en B. Verantwoording, Handleiding, Diagnostiek en Behandeling*. [*Klepel, form A and B, accountability, manual, diagnostics and treatment.]* Harcourt Test Publishers.

Veerbeek, J., Vogelaar, B., Verhaegh, J., &Resing, W. C. (2019). Process assessment in dynamic testing using electronic tangibles. *Journal of Computer Assisted Learning*, *35*(1), 127–142. https://doi.org/10.1111/jcal.12318

Vogelaar, B., Bakker, M., Hoogeveen, L., &Resing, W. C. M. (2017). Dynamic testing of gifted and average-ability children's analogy problem solving: Does executive functioning play a role? *Psychology in the Schools*, *54*(8), 837–851. https://doi.org/10.1002/pits.22032

Vogelaar, B., Veerbeek, J., Splinter, S. E., & Resing, W. C. M. (2020b). Computerised dynamic testing of children's potential for reasoning by analogy: the role of executive functioning. *Journal of Computer Assisted Learning*, *37*(3), 632–644. https://doi.org/10.1111/jcal.12512

Vygotsky, L. S. (1980). *Mind in Society*. University Press.

Werth, R. (2018). Rapid improvement of reading results in children with dyslexia by altering the reading strategy: A novel approach to diagnoses and therapy of reading deficiencies. *Restorative Neurology and Neuroscience*, *36*(6), 679–691. https://doi.org/10.3233/rnn-180829

Yang, L., Li, C., Li, X., Zhai, M., An, Q., Zhang, Y., Zhao, J., & Weng, X. (2022). Prevalence of developmental dyslexia in primary school children: A systematic review and meta-analysis. *Brain Sciences*, *12*(2), 240. https://doi.org/10.3390/brainsci12020240

Zarić, J., Hasselhorn, M., & Nagler, T. (2020). Orthographic knowledge predicts reading and spelling skills over and above general intelligence and phonological awareness. *European Journal of Psychology of Education*, *36*(1), 21–43. https://doi.org/10.1007/s10212-020-004647