European Journal of Psychology and Educational Research
Volume 6, Issue 4, 165 - 179.
ISSN: 2589-949X
https://www.ejper.com

Online Dynamic Testing of Reading and Writing, Executive Functioning and Reading Self-Concept in Typically Developing Children and Children Diagnosed with Dyslexia

Mirjam de Vreeze-Westgeest
Leiden University, NETHERLANDS

Sara Mata
University of Granada, SPAIN

Francisca Serrano
University of Granada, SPAIN

Wilma Resing
Leiden University, NETHERLANDS

Bart Vogelaar*
Leiden University, NETHERLANDS

Received: July 28, 2023 ▪ Revised: August 5, 2023 ▪ Accepted: September 29, 2023

Abstract: The current study aimed to investigate the effectiveness of an online dynamic test in reading and writing, differentiating in typically developing children (n = 47) and children diagnosed with dyslexia (n = 30) aged between nine and twelve years. In doing so, it was analysed whether visual working memory, auditory working memory, inhibition, cognitive flexibility, and reading self-concept were related to the outcomes of the online dynamic test. The study followed a pretest-training-posttest design with two conditions: experimental (n = 41), who received training between the pretest and posttest, and control (n = 37), who received training after the posttest. Results showed that typically developing children and children diagnosed with dyslexia in both conditions could improve their reading and writing accuracy scores, while the training in prosodic awareness might have tapped into children's potential for learning. Moreover, results revealed that in children diagnosed with dyslexia, training in the domain of writing competence could compensate for cognitive flexibility. However, training was not found to compensate for reading self-concept in children diagnosed with dyslexia.

Keywords: *Online dynamic testing, developing children, dyslexia.*

To cite this article: de Vreeze-Westgeest, M., Mata, S., Serrano, F., Resing, W., & Vogelaar, B. (2023). Online dynamic testing of reading and writing, executive functioning and reading self-concept in typically developing children and children diagnosed with dyslexia. *European Journal of Psychology and Educational Research, 6*(4), 165-179. https://doi.org/10.12973/ejper.6.4.165

Introduction

To achieve academic success, literacy development is required in most educational environments (Lindeblad et al., 2019). Therefore, measuring the effectiveness of literacy instruction is crucial in education. For this purpose, in particular, static tests are used. Static tests are standardised product-oriented tests administered after a period of instruction, which aim to measure the child's actual level of functioning and obtain an insight into possible gaps in knowledge (Petersen et al., 2016; Resing, 2000). Although these tests have clear advantages, such as a one-time administration format and clear-cut results used to classify and identify children (Caffrey et al., 2008), there are some drawbacks to using these tests for dyslexia identification purposes. For instance, it has been stated that static tests tend to be biased towards children with specific learning disabilities like dyslexia (Navarro & Lara, 2017; Resing et al., 2020).

However, as the provision of feedback is not permitted in most static test procedures (Nazari, 2012), they do not provide insight into the child's potential for learning, which, as critics argue, is necessary information to gain insight into educational needs (Jeltova et al., 2007). Therefore, researchers advocate using dynamic tests, which incorporate training into the testing format to measure a child's responsiveness to instruction (Resing et al., 2020). Therefore, the main aim of this study was to gain more insight into the effects of online dynamic reading and writing test focusing on phonemic awareness, prosodic awareness, writing competence and context-dependent words amongst typically

* **Corresponding author:**
Bart Vogelaar, Leiden University, Netherlands. ✉ b.vogelaar@fsw.leidenuniv.nl

developing or children diagnosed with dyslexia. In doing so, this study specifically focused on the effects of online administration, the roles of executive functioning, and reading self-concept in uncovering the potential for learning reading and writing skills. Online administration was specifically focused on, as due to the COVID-19 pandemic, there have been significant demands on educational professionals in terms of online teaching, measurement and intervention.

In this introduction, first online dynamic testing of reading and writing was discussed. After that, a brief description of literacy development in typically developing children and children diagnosed with dyslexia, executive functioning, and reading self-concept was given.

Dynamic Testing of reading and writing

A frequently used dynamic testing format concerns the pretest-training-posttest design (Resing et al., 2020), which enables tapping into the zone of proximal development (Vygotsky, 1978). The ZPD, which can be defined as the difference between the ability to solve a task individually, the actual zone of development, and the ability to solve a task after reciprocal help from a more knowledgeable other, the zone of potential development (Vygotsky, 1978), research employing dynamic testing of literacy and reading difficulties showed that dynamic measures of reading and writing, such as phonological awareness, predicted future academic achievements even better than conventional static measures (Caffrey et al., 2008). A drawback of dynamic testing methods is that they are time-consuming. Therefore, there was an interest in computerised test environments and online test methods, in which the computer is used as an assessment tool in a computerised test environment or as a tool to establish online contact (Ebadi & Rahimi, 2019), and research indicates that online dynamic tests strengthen particular skills, such as writing, reading or mathematics (Ebadi & Rahimi, 2019; Passig et al., 2016; Poehner & Lantolf, 2013; Puhan et al., 2007). Still, research into online dynamic administered reading and writing tests is scarce, and the usefulness of an online dynamic test of reading and writing for primary school children has not been investigated yet.

Developing Literacy

Elementary skills in early literacy, the ability to read and write, include phonological awareness, prosodic skills, letter knowledge, decoding and oral language skills (Arnoutse, 2004; Wackerle-Hollman et al., 2015). Phonological awareness, i.e. recognising and manipulating sounds in words, develops in several steps. First, children learn to understand that sentences are composed of words, words of syllables, and then rhyme sounds before segmenting words into phonemes, thus developing the letter knowledge necessary for reading and writing (Nicholas & Rouse, 2021). Prosodic awareness (rhythm perception) is the child's ability to distinguish or indicate an emphasis while listening, speaking, reading or writing (Godde et al., 2020). In addition, executive functions such as verbal fluency, working memory, inhibition and affective aspects, for example, reading self-concept, may influence literacy development (Lindeblad et al., 2019; Serrano & Defior, 2008). However, developing literacy skills is not self-evident for all children.

Dyslexia

For children diagnosed with dyslexia, unlike typically developing children, learning phonological and prosodic skills is challenging. Developmental dyslexia is a specific, neurodevelopmental language-based learning disability characterised by continual difficulties with fluent and exact word recognition and poor decoding and writing abilities despite remediation, intact sensory abilities and adequate instruction (Lyon et al., 2003; Snowling, 2013). The central deficits underlying dyslexia include weaknesses in grapheme-phoneme knowledge, rapid automatised naming and phonological awareness (Kudo et al., 2015). Effective clinical dyslexia interventions are mainly psycholinguistic intervention methods that aim to reinforce these weaknesses, for instance, by explicitly teaching phonemics (Melby-Lervåg et al., 2012; Tijms et al., 2021;). Furthermore, research has shown that children diagnosed with dyslexia, compared to their typically developing peers, often also experience difficulties with, for example, self-esteem (Zuppardo et al., 2020), self-perception (Gibby-Leversuch et al., 2021) and executive functioning (Johann et al., 2020).

Executive Functions (Working Memory, Inhibitory Control and Cognitive Flexibility)

Executive functions are higher-order cognitive skills necessary to coordinate and control everyday behaviour essential in curricular activities (Diamond, 2013). They are good predictors of school success (Cortés Pascual et al., 2019) and, more specifically, literacy development (Ribner et al., 2017). Therefore, researchers and teachers are highly interested in programs strengthening children's executive functioning (Johann et al., 2020). Researchers generally distinguish three core executive functions, working memory, inhibition and cognitive flexibility, on which higher-order functions are built (Diamond, 2013; Goswami, 2019).

Working memory is defined as processing and temporally storing information or data which is no longer perceptually present (Diamond, 2013). Working memory is necessary to process words to comprehend a text visually (Peng et al., 2018).

Inhibitory control enables one to control attention, behaviour, and thoughts. The construct is divided into response inhibition, responsible for suppressing a behavioural response, and cognitive inhibition, responsible for directing attention to relevant information (Friso-van den Bos & van de Weijer-Bergsma, 2020). Its implications for reading and writing seem clear: While reading or writing, one must inhibit stimuli to pay attention to what is being read or written (Friso-van den Bos & van de Weijer-Bergsma, 2020).

Cognitive flexibility concerns adapting approaches or perspectives to various tasks (Diamond, 2013). Research suggests that cognitive flexibility is essential in early literacy development as starting readers and writers must process a collection of letter-sound pairs and consider various articulations of letter strings (Vadasy et al., 2022). Cognitive flexibility is often measured by verbal fluency tasks (Diamond, 2013). Verbal fluency describes the ability to induce items according to specific rules (Smith-Spark et al., 2017).

Research showed that children diagnosed with dyslexia demonstrated weaknesses in working memory (Peng et al., 2018), inhibitory control (Peng et al., 2018), and cognitive flexibility (Dadgar et al., 2022). In addition, reduced access to phonemically structured representations of speech, phonological processing and letter and semantic fluency was found in children diagnosed with dyslexia (Melby-Lervåg et al., 2012; Shareef et al., 2018). Moreover, the importance of executive functioning concerning academic achievement can also be found in its association with social-emotional factors; for example, weaknesses in executive functions have been associated with lower academic self-concept (Bailey et al., 2018).

Reading Self-Concept

Reading self-concept can be defined as the general image of oneself as a reader (Katzir et al., 2018). Young children establish reading self-concept through their degree of fast reading and reading accuracy (Katzir et al., 2018). Implications of low reading self-concept include avoidance of reading tasks (Grills et al., 2014), lower reading motivation, and, in turn, reading skills (Katzir et al., 2018).

Surprisingly, there is little research on reading self-concept in children with dyslexia. Gibby-Leversuch et al. (2021) systematic review of self-perception concluded that being diagnosed with dyslexia may affect self-perception negatively. Furthermore, Zuppardo et al. (2020) stated that dyslexia also affects self-esteem. Moreover, whether reading self-concept plays a role in dynamic tests, which are expected to compensate for social-emotional factors such as test anxiety (Vogelaar et al., 2017) and weaknesses in executive functioning (Vogelaar et al., 2019), remains unclear.

Aims of the Current Study

The current study aimed to gain insight into the potential effects of an online-administered dynamic reading and writing test in children diagnosed with dyslexia and typically developing children. In so doing, we explored the potential relationships between executive functioning, reading self-concept and static and dynamic measures of reading and writing. The first research question addressed children's progression from pretest to posttest. We hypothesised that all groups of children would improve from pretest to posttest in the number of correct answers on phonemic awareness, prosodic awareness, writing competence, and context-dependent words (Mata & Serrano, 2019). More specifically, we expected that children in the experimental condition, who received training between pretest and posttest, would show more improvement in the number of correct answers than their peers in the control condition (Mata & Serrano, 2019; Navarro & Lara, 2017; Petersen et al., 2018). Concerning potential differences between children with dyslexia and their typically developing peers, we expected that children diagnosed with dyslexia would, in general as well as in both conditions, show less progression than their typically developing peers due to their general lack of responsiveness to treatment (Aravena et al., 2018; Mata & Serrano, 2019).

The second research question concerned the potential relationship between static and dynamic reading and writing scores and executive functioning, specifically working memory, inhibition and cognitive flexibility. Pretest scores, as well as the posttest scores of the children in the control condition, were considered static measures, and the posttest scores of the children who were trained were considered dynamic measures. In general, the static reading and writing measures were expected to be positively associated with the executive function measures (Altemeier et al., 2008). Concerning the posttest of the trained children in the experimental condition, executive functioning was expected to be associated less strongly with posttest scores, considering that training was found to compensate for weaknesses in executive functions (Vogelaar et al., 2019). The scores of the typically developing children and those with dyslexia were analysed separately to explore potential differential correlational patterns.

Our final research question involved the potential relationship between static and dynamic measures of reading and writing and the static measure of reading self-concept. Generally, the static reading and writing measures were expected to be positively associated with a lower reading self-concept (Durik et al., 2006). Concerning the posttest scores of the trained children, it was expected that reading self-concept would be associated less strongly with the dynamic posttest scores. This would imply that the dynamic test could compensate for social-emotional factors (Vogelaar et al., 2017). The scores of the typically developing children and those with dyslexia were again analysed separately to explore potential differential relationships.

Methodology

Participants

The sample consisted of 78 participants (35 boys and 43 girls) with a mean age of 10.6 (*SD* = .76; 9-12 years). The children diagnosed with dyslexia (*n* = 30) were recruited by OnderwijsAdvies, an educational advisory service and dyslexia treatment institute in the Netherlands. The typically developing children (*n* = 48) were recruited from regular mainstream primary schools in the province of Zuid-Holland. Moreover, all children diagnosed with dyslexia were diagnosed with single severe dyslexia and belonged to the weakest 10% on reading or writing tests compared to their age-mates. The total distribution of children with and without dyslexia over the two conditions is displayed in Table 1.

Design and Procedure

This study had an experimental pretest-training-posttest design with two conditions: control and experimental, as can be seen in Table 1. The study consisted of two sessions: During the first session, a preliminary online assessment consisting of the Picture Span and Digit Span of the Wechsler Intelligence Scale for Children-V-NL (WISC-V-NL; Wechsler, 2014), Stroop-Color-Word test (Stroop, 1935), Ideational Fluency, part of the Revisie Amsterdamse Kinder Intelligentie test (RAKIT-2; Resing et al., 2012), and the Reading Self-Concept Scale (Chapman & Tunmer, 1995) were administered. The online dynamic reading and writing test was administered during the second session. Prior to the first session, children were distributed over the control and experimental conditions by employing a randomised block design based on age and gender. Children in the experimental condition received training between the pretest and posttest. The children in the control condition received training after finishing the posttest to provide the children in the control group the opportunity also to receive training. Trained master's students in Psychology collected the data under the authors' supervision. Microsoft Teams was used to administer all online tasks.

Table 1. Schematic Overview of the Design of the Study

		Session 1: 30 minutes	**Session 2: 60-75 minutes**			
		Preliminary Assessment	**The online dynamic test of reading and writing:**			
			Pretest	**Training**	**Posttest**	**Training**
Experimental Condition (*n*=41)	Children diagnosed with dyslexia (*n*=16)	X	X	X	X	-
	Typically developing children (*n*=25)	X	X	X	X	-
Control Condition (*n*=37)	Children diagnosed with dyslexia (*n*=14)	X	X	-	X	X
	Typically developing children (*n*=23)	X	X	-	X	X

Note 1. The preliminary assessment consisted of the following instruments: Picture and Digit Span of the WISC-V-NL, Stroop-Color-Word test, Idea Production of the RAKIT-2 and the Reading Self-Concept Scale.

Instruments

Picture Span Wechsler Intelligence Scale for Children-V-NL (Wechsler, 2014): The Picture Span measures visual working memory. As part of the Picture Span, children are shown a series of objects, after which they have to remember from a new series of objects the objects they were shown previously and in which order. The subtest takes 10 minutes, contains 26 items of increasing difficulty level, and has a test-retest reliability of *r* = .60 (Wechsler, 2014).

Digit Span Wechsler Intelligence Scale for Children-V-NL (Wechsler, 2014): Digit Span measures auditory working memory. It consists of three subtests: Digit Span Forward, Digit Span Backward, and Digit Span Sequencing, which takes up to 10 minutes. Each subtest consists of nine items with an increasing difficulty level. After a sequence of numbers is provided to the child, the child is asked to repeat this verbally. Depending on the type of the subtest, the child was asked to repeat the sequences forward, backwards or from the smallest number to the largest. The Digit Span task has a test-retest reliability of *r* =. 79 (Wechsler, 2014).

Stroop-Color-Word Test (Stroop, 1935): In about five minutes, the Stroop-Color-Word test measures the inhibition of a prepotent reading response to engage a naming response. With 100 stimuli each, three cards must be read correctly as fast as possible during the test. The names of the colours red, green, yellow, and blue are written out in black on card one. Card two shows rectangles in these colours. The words red, green, yellow, and blue are printed in mismatched colours on card three. Interference will occur on the last card, where the dominant reaction should be inhibited in naming the colour rather than reading the word. The difference in time between the third and second cards was used to measure inhibitory ability. A lower score means a better inhibitory ability. The test-retest reliability of the Stroop-Color-Word-Test is *r* = .68 (Van der Elst et al., 2008).

Ideational Fluency (Resing et al., 2012): The Ideational Fluency subtest measures ideational verbal fluency in about five minutes. Within one minute, the child has to answer five questions as quickly and realistically as possible. For example, a question could be: What do you see in a zoo? It measures the ease and speed with which new ideas and corresponding answers can be produced within a specific category. The test-retest reliability is r = .82 (Resing et al., 2012). In the current study, ideational fluency was considered a measure of cognitive flexibility (see e.g. Diamond, 2013).

Reading Self-Concept Scale (Chapman & Tunmer, 1995): The Reading Self-Concept Scale is a self-assessment questionnaire that measures reading self-concept. The scale consists of 30 items matching three subscales: perception of reading skills, reading difficulties, and attitudes towards reading. The items are formulated as questions, such as 'Is reading difficult for you?'. The questions are read aloud to the children, where they answer on a five-point scale: 'yes, always', 'yes, often', 'not clear/not sure', 'no, not often' and 'no, never'. The test takes approximately 5 minutes. Each answer is scored from one to five, where one represents low self-esteem when reading and five represents high self-esteem when reading. The full-scale score is calculated from the average of the 30 items, ranging from one to five. The internal reliability of the entire Reading Self-Concept Scale is α = .89 (Chapman & Tunmer, 1995).

Online Dynamic Reading and Writing test (Mata & Serrano, 2019): The dynamic reading and writing test, initially developed in Spanish and translated and cross-translated into Dutch for the current study, aims to assess children's potential for learning reading and writing skills. Two of the four subtests cover basic reading skills: phonemic awareness and prosodic awareness. The two other subtests focus on writing skills, specifically knowledge of writing rules and homophones. The dynamic reading and writing test can be administered in about 60 to 80 minutes. Each subtest consists of three phases. The child solves the task independently in the test's first (pretest) and third (posttest) phases. The task at the posttest is the same as at pretest. For motivation, each subtest is stopped after three consecutive errors. The second phase consists of individual training: extra instruction and practice with the assistance of an adult in which the child is challenged to improve posttest scores. The training is standardised and administered hierarchically: training starts at an abstract level and ends at the task-specific level for each subtest.

Subtest 1: Phonemic Awareness: This reading subtest covers phonemic awareness of the type synthesis. In about 15-20 minutes, it evaluates the child's ability to construct words by identifying smaller units (phonemes). For example, which word will you get if you hear m/e? Fourteen words are presented in sounds, and the child must determine which word has been said while they cannot see the examiner's mouth. The training consists of four hints: Creating sentences with words presented on cards, dividing words into syllables, marking phonemes on cards, and finally, making (nonsense) words by throwing dice with syllables, vowels and consonants. The internal consistency of this subtest is α = .89 (Mata & Serrano, 2019).

Subtest 2: Prosodic Awareness: This reading subtest measures prosodic awareness and evaluates in about 15-20 minutes whether the child hears the emphasis in a word. After hearing eighteen words, the child has to determine which sound group is emphasised. The training consists of four hints: Tapping the table and pointing out the loudest tap, clapping words and counting the syllables, pointing out the loudest syllable on a card by putting a red plug and practising with cards, giving the child a starting point to find the emphasised sound group. The internal consistency of this subtest is α = .87 (Mata & Serrano, 2019).

Subtest 3: Writing Competence: This writing subtest evaluates writing competence in 15-20 minutes using phonological and writing rules in words and sentences. Twenty-five words are dictated to the child. Every word is said twice. The training consists of four hints: Discussing writing rules with cards circling the same letter clusters, completing words and verbs and practising with sentences to create an awareness of the link between graphemes and phonemes and the Dutch writing rules. The internal consistency of this subtest is α =.83 (Mata & Serrano, 2019).

Subtest 4: Context-Dependent Words: This writing subtest measures the child's orthographic ability to determine the correct form of a homophonic word in about 15-20 minutes. Homophonic words sound the same but have distinct meanings and spellings. Therefore, the context of eighteen sentences with a missing word must be used to determine the missing word's correct spelling. The correct answer is given in a row of three words, a word slightly similar to the homophones and the two homophones. During the training, nine pictures of word couples that sound the same, only with different writing and meaning, are presented. The hint focuses on the differences in the graphemes of the two homophones as the pictures fade into two or three letters in six steps. The internal consistency of this subtest is α .62 (Mata & Serrano, 2019).

Statistical analyses:

Before answering the research questions and investigating potential initial group differences, a one-way MANOVA was conducted. The dependent variables in this analysis included age, pretest scores on preliminary assessment tests, including visual and auditory working memory, inhibition, cognitive flexibility and reading self-concept, and the dynamic reading and writing pretest scores. The independent variables included Condition (experimental versus control condition) and Subgroup (typically developing children versus children diagnosed with dyslexia). Furthermore, a chi-square analysis was conducted to investigate whether boys and girls were equally distributed across the two conditions and subgroups.

Test-retest reliability for all dynamic reading and writing subtests was calculated separately using Pearson correlations for the experimental and control conditions.

To answer the first research question, Repeated Measures of Multivariate Analysis of Variance (RM MANOVA) were used. Session (pretest versus posttest) was included as a within-subjects factor, and Condition (experimental condition versus control condition) and Subgroup (typically developing versus diagnosed with dyslexia) as between-subjects factors. In addition, accuracy scores on subtests of Phonemic Awareness, Prosodic Awareness, Writing Competence, and Context-Dependent Words served as the dependent variables.

To answer the second and third research questions, Pearson product-moment correlations were included between the pre-and posttest reading and writing performance measures of the typically developing children and children diagnosed with dyslexia on the one hand and the executive function measures and reading self-concept on the other. In these analyses, children with dyslexia and the typically developing children were analysed separately. Furthermore, the assumptions of normality and homogeneity were checked for all dependent variables.

Findings/Results

Prior to conducting our analyses, assumptions for normality were checked through the Kolmogorov-Smirnov test. The findings indicated that assumptions were met for age D (48) = .977, $p > .05$, cognitive flexibility D (48) = .991, $p > .05$, reading self-concept D (48) = .971, $p > .05$, Prosodic Awareness D (48) = .911, $p > .05$ in typically developing children. In children diagnosed with dyslexia, assumptions for normality were met for age D (30) = .970, $p > .05$, reading self-concept, D (30) = .973, $p > .05$, Prosodic Awareness, D (30) = .941, $p > .05$ and Writing Competence D (30) = .960, $p > .05$ for children diagnosed with dyslexia. Furthermore, assumptions for homogeneity were checked through Levene's test. The assumptions for homogeneity check indicated that assumptions were met for age F (1,76) = 1.30, $p > .05$, cognitive flexibility F (1,76) = .024, $p > .05$, reading self-concept F (1,76) = .352, $p > .05$, Phonemic Awareness F (1,76) = .639, $p > .05$, and Prosodic Awareness F (1,76) = .124, $p > .05$).

Initial Group Comparisons

To investigate potential initial group differences, a one-way MANOVA was conducted. An analysis of the multivariate effects revealed no significant differences in these variables between the children in the two conditions (Wilks' λ = .95, F(5,70) = .687, p = .64, η_p^2 = .05). The multivariate Subgroup effect was however, significant, Wilks' λ = .44, F(5,70) = 17.56, $p < .001$, η_p^2 = .56). The univariate between-subjects Subgroup effects in combination with a visual examination of the mean scores revealed that children diagnosed with dyslexia had lower scores on visual working memory, (F(1,74) = 13.08, p <.001, η_p^2 =.15), auditory working memory (F(1,74) = 16.40, p <.001, η_p^2 = .18), inhibition (F(1,74) = 11.10, p = .001, η_p^2 =.13) and reading self-concept (F(1,74) =70.40 p = <.001, η_p^2 =. 49), but not on cognitive flexibility (F(1,74) = 1.17, p = .28, η_p^2 = .02). Means and standard deviations can be found in Table 2. The chi-square analysis revealed a similar distribution of boys and girls across conditions ($\chi 2(1)$ = 2.70, p = .10) as well as across subgroups ($\chi 2(1)$ = .52, p = .47).

Table 2. Mean Scores and Standard Deviations of Preliminary Investigation (Executive Functions and Reading Self-Concept) per Condition and Subgroup

		(1) Control Condition	(2) Experimental Condition	(3) Typically developing	(4) Diagnosed with dyslexia	(5) Total
n		37	41	48	30	78
Visual Working	M	31.78	31.54	33.65	28.47	31.65
Memory	SD	7.12	6.58	5.67	7.31	6.80
Auditory Working	M	27.03	26.59	28.81	23.57	26.79
Memory	SD	6.71	5.83	6.41	4.33	6.23
Cognitive	M	71.78	74.68	71.67	75.93	73.31
flexibility	SD	17.25	17.50	16.84	18.07	17,33

Table 2. Continued

		(1) Control Condition	(2) Experimental Condition	(3) Typically developing	(4) Diagnosed with dyslexia	(5) Total
Inhibition	M	60.19	68.00	57.10	75.80	64.30
	SD	22.88	28.12	24.62	24.01	25.90
Reading Self-Concept	M	3.67	3.55	3.93	3.08	3.61
	SD	.57	.62	.40	.48	.60

Psychometric Properties of the Online Dynamic Reading and Writing Test

The psychometric properties of the online dynamic reading and writing test were analysed. Positive, strong correlations between pretest and posttest scores were found for all subtests in the control condition (Phonemic Awareness: $r(35) = .79$, $p < .001$; Prosodic Awareness: $r(35) = .76$, $p < .001$; Writing Competence $r(35) = .96$, $p < .001$; Context-Dependent Words: $r(35) = .94$, $p < .001$), indicating sufficient test-retest reliability. In the experimental condition, significant positive correlations between pretest and posttest scores were again found for all subtests (Phonemic Awareness: $r(39) = .61$, $p < .001$; Prosodic Awareness: $r(39) = .68$, $p < .001$; Writing Competence $r(39) = .93$, $p < .001$; Context-Dependent Words: $r(39) = .47$, $p < .001$), indicating sufficient test-retest reliability. Fisher's *r*-to-*z* transformations were performed to investigate if these correlations differed significantly between the two conditions. No or almost significant differences were found for subtests of Phonemic Awareness ($z = 1.58$, $p = .057$), Prosodic Awareness ($z = .74$, $p = .230$), and Writing Competence ($z = 1.04$, $p = .150$). The correlation between pretest and posttest scores was larger in the control condition than in the experimental condition for the subtest Context-Dependent Words ($z = 5.02$, $p < .001$), providing a first indication of training effectiveness. Cronbach's alpha coefficients were calculated to analyse the internal consistency of the subtests at the pretest with scores ranging from $\alpha = .54$ for the subtest Phonemic Awareness, $\alpha = .66$ for the subtest Writing Competence, $\alpha = .70$ for the subtest Context-Dependent Words and finally $\alpha = .93$ for the subtest Prosodic Awareness.

Effect of Training

The effect of training on children's progression in reading and writing was examined through Repeated Measures of Multivariate Analysis of Variance (RM MANOVA). All effects are displayed in Table 3. The multivariate results indicated significant Session ($p = .004$, $\eta_p^2 =.11$) and Session x Condition effects ($p = .003$, $\eta_p^2 = .12$). These findings indicated that there was a significant progression from pretest to posttest in at least one of the subtests and that there was a significant differential progression from pretest to posttest between the experimental and control condition in at least one of the subtests. A visual examination of the mean scores, as can be seen in Table 4 and Figure 1, indicated that the children who were trained progressed more than the children who were not, providing a first indication that training might be effective. Moreover, no significant Session x Subgroup ($p = .351$, $\eta_p^2 = .01$) or Session x Condition x Subgroup ($p = .471$, $\eta_p^2 = .01$) effects were found, which, as can be seen in the mean scores in Figure 1, indicated that the typically developing children and children diagnosed with dyslexia, regardless of whether they were trained, demonstrated similar improvement in accuracy from pretest to posttest. Follow-up univariate effects at the subgroup level were described below.

Table 3. Multivariate, Univariate and Between-Subject Effects RM MANOVA Outcomes

	Wilk's λ	***F***	***p***	**η_p^2**
Multivariate effects				
Session	.89	8.97	.004	.11
Session x Condition	.89	9.63	.003	.12
Session x Subgroup	.99	.88	.351	.01
Session x Condition x Subgroup	.99	.53	.471	.01
Univariate effects				
Phonemic Awareness				
Session		19.16	< .001	.21
Session x Condition		.03	.857	<.001
Session x Subgroup		1.77	.188	.02
Session x Condition x Subgroup		.10	.759	.001
Prosodic Awareness				
Session		.02	.897	<.001
Session x Condition		9.02	.004	.11
Session x Subgroup		.11	.739	.002
Session x Condition x Subgroup		.63	.431	.01

Table 3. Continued

	Wilk's λ	*F*	*p*	η_p^2
Writing Competence				
Session		19.55	< .001	.21
Session x Condition		.10	.758	.001
Session x Subgroup		1.30	.257	.02
Session x Condition x Subgroup		.52	.473	.01
Context-Dependent Words				
Session		1.91	.171	.03
Session x Condition		1.85	.178	.02
Session x Subgroup		.004	.949	< .001
Session x Condition x Subgroup		.10	.757	.001
Between Subject Effects				
Phonemic Awareness				
Condition		1.67	.200	.02
Subgroup		4.05	.048	.05
Condition x Subgroup		2.37	.128	.03
Prosodic Awareness				
Condition		.34	.563	.01
Subgroup		2.26	.137	.03
Condition x Subgroup		2.58	.113	.03
Writing Competence				
Condition		.47	.496	.01
Subgroup		56.33	< .001	.43
Condition x Subgroup		3.51	.065	.05
Context-Dependent Words				
Condition		1.52	.222	.02
Subgroup		38.73	< .001	.34
Condition x Subgroup		1.03	.313	.01

Phonemic Awareness: The univariate effects revealed a significant Session effect (p < . 001, η_p^2 = .21), but no significant effects of Session x Condition (p = .857, η_p^2 < .001), Session x Subgroup (p = .188, η_p^2 = .02), or Session x Condition x Subgroup (p = .759, η_p^2 = .001). These findings indicate that all groups of children progressed from pretest to posttest. Contrary to our hypothesis, we did not observe significant differences in the level of progression between the experimental and control conditions. Also, contrary to our hypothesis, no significant differences in progression from pretest to posttest were found between children diagnosed with dyslexia and typically developing children. In addition, a significant between-subjects effect for Subgroup (Phonemic Awareness, (p = .048, η_p^2 = .05) indicated, in combination with a visual check of the mean scores, that the children diagnosed with dyslexia, as expected, in general, had lower scores than their typically developing age-mates.

Prosodic Awareness: The univariate effects revealed no significant effects of Session (p = .897, η_p^2 < .001). However, a significant Session x Condition effect (p = .004, η_p^2 = .11) was found. Furthermore, no significant effects of Session x Subgroup (p = .739, η_p^2 =.002) or Session x Condition x Subgroup (p = .473, η_p^2 = .01) were found. These findings align with our hypothesis that children in the experimental condition would show more growth from pretest to posttest than children in the control condition for this subtest. This is also reflected in the scores shown in Table 3. No significant differences in improvement in scores from pretest to posttest were observed between children diagnosed with dyslexia and typically developing children. Moreover, the fact that the between-subjects effect for Subgroup was not significant (Prosodic Awareness, (p = .563, η_p^2 = .01) demonstrated that, unlike our expectations, typically developing children did not outperform those diagnosed with dyslexia.

Writing Competence: The univariate effects revealed a significant Session effect (p < . 001, η_p^2 = .21). However, no significant effects of Session x Condition (p = .758, η_p^2 = .001), Session x Subgroup (p = .257, η_p^2 = .02), or Session x Condition x Subgroup (p = .473, η_p^2 = .01) was found. These findings indicate that all children showed progression from pretest to posttest. Contrary to our hypothesis, we observed no significant differences between the control and experimental conditions. Also, contrary to our hypothesis, no significant differences in progression from pretest to posttest were found between children diagnosed with dyslexia and typically developing children. In addition, a significant between-subjects effect for Subgroup (Writing Competence, (p = < . 001, η_p^2 = .43), indicated, in combination with a visual check of the mean scores, that the children diagnosed with dyslexia, as expected, had lower scores than their typically developing age-mates.

Context-Dependent Words: No significant univariate effects were found for this subtest. When accounting for Subgroup and Condition, no significant differences in improvement in scores from pretest to posttest were found. The significant

Subgroup between-subjects effect (Context-Dependent Words (p = < . 001, η_p^2 = .34), in combination with a visual check of the mean scores, however, further demonstrated that children diagnosed with dyslexia, as expected, in general, had lower scores than their typically developing age-mates.

Table 4. Basic Statistics for Scores on all Online Dynamic Reading and Writing Subtests at Pre- and Posttest

		Experimental Condition		Control Condition	
		Pretest	**Posttest**	**Pretest**	**Posttest**
Typically developing children					
Phonemic Awareness	M (SD)	11.96 (1.97)	12.52 (2.40)	12.04 (2.06)	12.65 (1.50)
Prosodic Awareness	M (SD)	9.68 (5.89)	10.80 (6.74)	12.26 (5.45)	10.91 (6.99)
Writing Competence	M (SD)	21.84 (2.44)	22.40 (2.69)	22.74 (1.86)	23.17 (1.47)
Context-Dependent Words	M (SD)	15.64 (1.19)	16.40 (1.32)	16.09 (1.35)	16.17 (1.07)
Children diagnosed with dyslexia					
Phonemic Awareness	M (SD)	11.44 (2.22)	12.63 (1.41)	10.29 (2.40)	11.28 (2.40)
Prosodic Awareness	M (SD)	9.19 (5.87)	11.56 (6.01)	8.43 (4.77)	6.57 (6.49)
Writing Competence	M (SD)	17.81 (3.99)	18.50 (3.60)	15.86 (4.20)	16.86 (4.87)
Context-Dependent Words	M (SD)	11.81 (4.56)	12.81 (4.23)	13.50 (3.39)	13.42 (3.08)

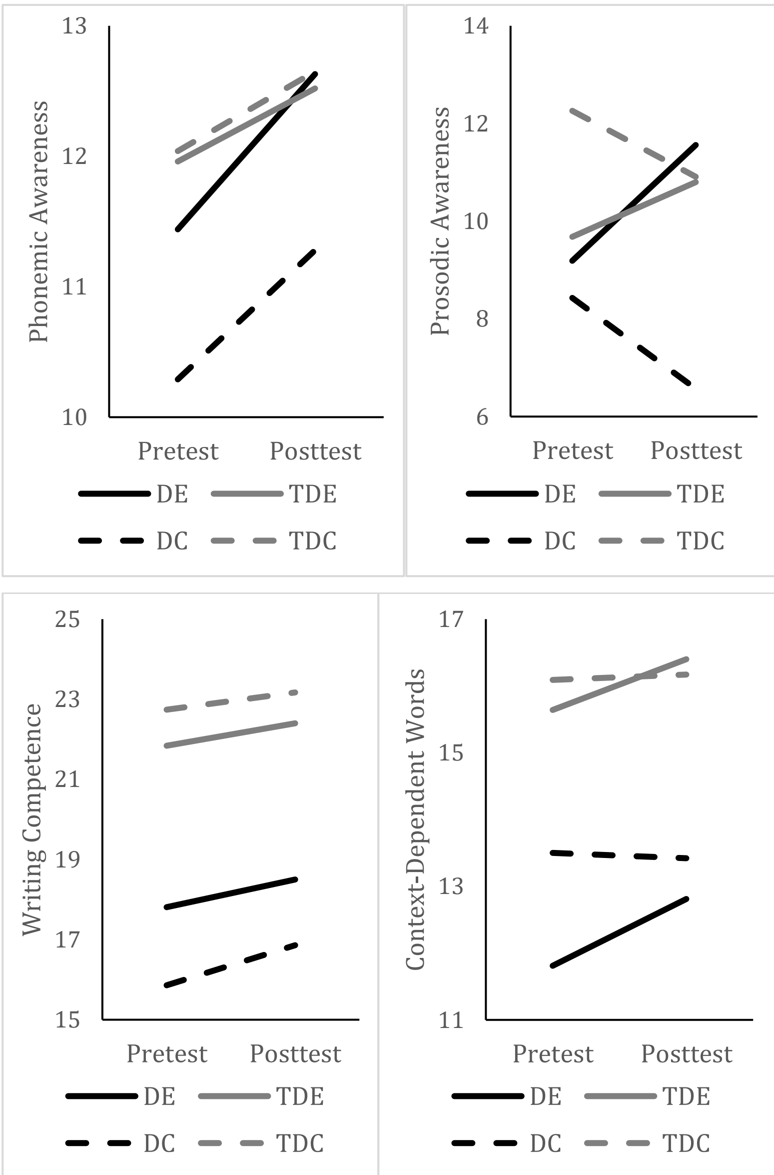

Figure 1. Mean Scores of Dynamic Reading and Writing Subtests

Note. DE= children diagnosed with dyslexia Experimental Condition, DC= children diagnosed with dyslexia Control Condition, TDE= typically developing children Experimental Condition, TDC= typically developing children Control Condition.

The Relationship between Static and Dynamic Reading and Writing Scores, Executive Functioning and Reading Self-Concept

Pearson product-moment correlations were calculated between the pre-and posttest subtests to investigate the relationship between the dynamic reading and writing measures on the one hand and executive function measures and reading self-concept on the other hand (see Table 5). Separate analyses were performed for Condition and Subgroup.

Table 5. Pearson Product-Moment Correlation Matrix between Executive Functions, Reading Self-Concept Pretest and Posttest Dynamic Reading and Writing Measures (divided by Condition and Subgroup)

	Pretest				**Posttest experimental condition**				**Posttest 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												
Visual Working Memory	.31*	.31*	.26	.20	.12	.46*	.35	.36	.29	.40	.24	-.13
AuditoryWorking Memory	.24	.17	.32*	.38*	.27	.06	.43*	.33	.04	.30	.17	.04
Cognitive Flexibility	-.24	-.04	-.18	-.03	-.14	-.08	.23	-.16	-.28	-.10	-.08	.05
Inhibition	.10	.09	-.07	-.13	-.19	-.09	.07	.28	.05	.15	-.31	-.34
Reading Self-Concept	.12	-.18	.34*	.28	-.14	-.21	.33	.27	.10	.07	.55**	.08
Children diagnosed with dyslexia												
Visual Working Memory	.22	.05	.10	-.02	.09	.16	.01	.33	.31	.03	.17	.16
AuditoryWorking Memory	.25	.14	.44*	.00	.03	.03	.40	.15	.31	.16	.27	.04
Cognitive Flexibility	.07	.17	.40*	.07	-.08	.23	.02	-.14	.36	-.05	.69**	.23
Inhibition	.03	-.07	.04	-.06	.14	.42	.28	.40	-.52	-.14	-.30	.09
Reading Self-Concept	.04	.19	-.01	-.19	.14	.27	-.10	-.09	.40	.30	.41	.10

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

Overall, positive moderate relationships, as anticipated, were found between the online dynamic subtests and visual and auditory working memory in the typically developing children. In the children diagnosed with dyslexia, positive moderate relationships between the online dynamic subtests and visual working memory, auditory working memory and cognitive flexibility were found. Results indicated that typically developing children with stronger visual working memory performed better on Phonemic Awareness and Prosodic Awareness at pretest, and stronger auditory working memory was related to performance on Context-Dependent Words. Concerning the children diagnosed with dyslexia, stronger auditory working memory and cognitive flexibility were related to Writing Competence performance. In addition, typically developing children with a higher reading self-concept performed better on Writing Competence. In the children diagnosed with dyslexia, we saw an opposite outcome, where we found small negative correlations between reading self-concept and writing tasks. Relationships between the static reading and writing posttest performances of the untrained children diagnosed with dyslexia in the control condition and executive functions and reading self-concept were generally stronger than for the dynamic posttest performances of the trained children in the experimental condition. Results indicated that training in Writing Competence could compensate for weaknesses in auditory working memory, visual working memory and cognitive flexibility in children diagnosed with dyslexia. Moreover, training in Phonemic Awareness compensated for visual and auditory memory; the latter also applied to the training in Prosodic Awareness. Furthermore, we found that training in Phonemic Awareness in typically developing children seemed to compensate for visual working memory and cognitive flexibility, and training in Prosodic Awareness and Context-Dependent Words seemed to compensate for auditory working memory.

Discussion

The current study investigated the usefulness of an online dynamic reading and writing test. We thereby expanded on the existing research on dynamic literacy testing by incorporating phonemic and prosodic awareness and knowledge of writing words and homophones into the online dynamic reading and writing test for primary school children. The results indicated that the online reading and writing training had improved the performances of typically developing children and children diagnosed with dyslexia on Phonemic Awareness, Writing Competence and Context-Dependent

Words in the experimental and control conditions. At the same time, only those trained in Prosodic Awareness demonstrated considerable performance improvements beyond the effect of practice, suggesting that the extra instruction and practice with the assistance of an adult in Prosodic Awareness might have tapped into children's potential for learning. Unexpectedly, children diagnosed with dyslexia showed similar performance improvement as their age-related peers. This is an essential finding because training effectiveness is not always found in children diagnosed with dyslexia, as they show persistent difficulties in reading and writing (Aravena et al., 2018). This finding underlines the value of reciprocal learning of reading and writing skills in children diagnosed with dyslexia. The unexpected performance improvement of the children in the control condition might be explained by a practice effect. Direct repetition and recognising test items could have improved performance scores. On the other hand, the decrease in scores on Prosodic Awareness might be caused by a reduction in motivation; completing this subtest twice in a row might have been less attractive.

Furthermore, the current study aimed to understand the relationship between static and dynamic reading and writing measures and executive functioning. Our results support prior research, which indicates the importance of working memory concerning reading and writing skills. Indeed, reading and writing require remembering what has been read or heard, implicating working memory (Peng et al., 2018).

The performances on the online dynamic reading and writing posttest seemed less dependent on executive functioning. This finding advocates the use of dynamic testing principles as scores were less biased by the level of executive functioning. Training in Phonemic Awareness and Prosodic Awareness seemed to compensate for weaknesses in executive functions in typically developing children and children diagnosed with dyslexia. These results are supported by Sadasivan et al. (2012), who found that phonological awareness training, for example, could enhance reading and visual working memory skills. The training content, which included teaching reading and writing skills on an abstract level and then working towards a concrete level, and the visually supported instructions might have contributed to the compensatory effect of training. This finding is intriguing, given the importance of well-developed executive functions in literacy development (O'Brien & Yeatman, 2021).

In some studies, it was found that children diagnosed with dyslexia are known to experience executive functioning problems like cognitive flexibility (Dadgar et al., 2022). In the current study, we did not, however, find any significant differences in the cognitive flexibility of children diagnosed with dyslexia and their typically developing peers. Needless to say, this finding requires further research, but could be due to the fact that cognitive flexibility was operationalised as verbal fluency in the current study. Research has suggested that verbal fluency tasks rely more on children's vocabulary than language knowledge, allowing children with dyslexia to complete this test at a comparable level to typically developing children (Medina & Guimarães, 2021).

Lastly, the current study aimed to understand the relationship between static and dynamic reading and writing measures and reading self-concept. However, unexpectedly, reading self-concept correlated positively with the static writing scores of the typically developing children. Although writing skills complement reading skills (Galuschka et al., 2020), this finding needs further investigation. Given the effect of lower reading self-concept on motivation (Bagazi, 2022), future studies may want to explore further the impact of explicit writing instruction on reading self-concept.

No relationship was found between the posttest online dynamic reading scores and reading self-concept. This could mean that reading self-concept did not negatively affect the ability to profit from repeated practice or instruction. Perhaps this was due to training being too short to impact, the fact that those diagnosed with dyslexia might have no clear insight into their reading and writing performance (Grills et al., 2014) or the relatively young age of the participating children. As a strong relationship between academic self-concept and academic achievement in distance learners was found (Ajmal & Rafique, 2018), the online administration of the reading and writing subtests was not expected to affect these results.

Conclusion

This study contributed to the existing research on dynamic testing of reading and writing in an online environment. It was demonstrated that children diagnosed with dyslexia could equally benefit from online dynamic reading and writing training compared to typically developing children. More importantly, it seemed that online administration did not appear to be an obstacle to improving reading and writing performances, implying that the potential for learning can be assessed in an online environment. The current study provided a first indication that dynamic testing principles can be used successfully to gain insight into the reading and writing skills of typically developing children and those with dyslexia. Moreover, it seems that, to some extent, dynamic testing seems to compensate for weaknesses in executive functioning.

Recommendations

Therefore, it is recommended that teachers or educational psychologists use dynamic testing principles when assessing the reading and writing abilities of children who are in the process of learning to read and write, especially if they are known or suspected to have weaknesses in executive functions. These principles can, as the current study demonstrates, also be applied in an online environment, for example, in times of social distancing or if geographical distance is an issue to consider.

Furthermore, the results of this study can be interpreted as a step towards more research in the Netherlands in the field of (online) dynamic testing of reading and writing. In doing so, we specifically recommend that future researchers adjust the difficulty of the test items, which would make the online dynamic reading and writing test available for a wider age range. Furthermore, it is recommended that future researchers evaluate the type and amount of hints given in training to create a better connection between hints and the test items. Moreover, as sample size might have contributed to the results, future researchers should aim for a larger sample size to obtain more statistical power.

Limitations

Although our study might have been the first online dynamic test which combined reading and writing skills in the Dutch language area, the following limitations of the study should be kept in mind when interpreting the results. First, a ceiling effect might have occurred, especially regarding the results of the typically developing children, as the test items belonging to the other subtests might have been too easy for them, which left no room for further improvement from pretest to posttest. Second, relatively small subgroups were used due to the low number of participants.

Ethics Statements

The study was reviewed and approved by the ethics committee of the Institute of Psychology, Faculty of Social and Behavioural Sciences of Leiden University, under number 2021-01-21-B. Vogelaar-V1-2900. Furthermore, informed consent was obtained from all subjects and their parents/legal guardians.

Conflict of Interest

The authors declare no conflicts of interest.

Authorship Contribution Statement

De Vreeze-Westgeest: Data acquisition, analysis, interpretation, drafting of the manuscript. Mata: Critical revision of the manuscript, data analysis/interpretation. Serrano: Critical revision of the manuscript, data analysis/interpretation. Resing: Critical revision of the manuscript, data analysis/interpretation. Vogelaar: Concept and design, critical revision of the manuscript, data analysis/interpretation, supervision, final approval.

Acknowledgements

This research has been partially funded by the Project Grant number PID2021-126589OB-I00; Spanish Programa Estatal para Impulsar la Investigación Científico-Técnica y su Transferencia, del Plan Estatal de Investigación Científica, Técnica y de Innovación 2021-2023.

References

Ajmal, M., & Rafique, M. (2018). Relationship between academic self-concept and academic achievement of distance learners. *Pakistan Journal of Distance and Online Learning, IV* (11), 225-244.

Altemeier, L. E., Abbott, R. D., & Berninger, V. W. (2008). Executive functions for reading and writing in typical literacy development and dyslexia. *Journal of Clinical and Experimental Neuropsychology, 30*(5), 588–606. https://doi.org/10.1080/13803390701562818

Aravena, S., Tijms, J., Snellings, P., & Van der Molen, M. W. (2018). Predicting individual differences in reading and writing skill with artificial script–based letter–speech sound training. *Journal of Learning Disabilities, 51*(6), 552–564. https://doi.org/10.1177/0022219417715407

Arnoutse, C. A. J. (2004). *Ontwikkeling van beginnende geletterdheid* [Development of early literacy]. Thieme Media Center.

Bagazi, A. (2022). Reading self-concept and motivation: A perspective from students with reading difficulties. *International Journal of Education and Practice, 10*(4), 334–349. https://doi.org/10.18488/61.v10i4.3197

Bailey, B. A., Andrzejewski, S. K., Greif, S. M., Svingos, A. M., & Heaton, S. C. (2018). The role of executive functioning and academic achievement in the academic self-concept of children and adolescents referred for neuropsychological assessment. *Children*, *5*(7), Article 83. https://doi.org/10.3390/children5070083

Caffrey, E., Fuchs, D., & Fuchs, L. S. (2008). The predictive validity of dynamic assessment. *The Journal of Special Education*, *41*(4), 254–270. https://doi.org/10.1177/0022466907310366

Chapman, J. W., & Tunmer, W. E. (1995). Development of young children's reading self-concepts: An examination of emerging subcomponents and their relationship with reading achievement. *Journal of Educational Psychology, 87*(1), 154–167. https://doi.org/10.1037/0022-0663.87.1.154

Cortés Pascual, A., Moyano Muñoz, N., & Quílez Robres, A. (2019). The relationship between executive functions and academic performance in primary education: Review and meta-analysis. *Frontiers in Psychology, 10,* Article 1582. https://doi.org/10.3389/fpsyg.2019.01582

Dadgar, H., Karimzadegan, A., Soleymani, Z., & Tehranidoost, M. (2022). Relationship between cognitive flexibility, attention shifting, and planning with accuracy, speed, and reading comprehension in normal children and children with dyslexia. *The Scientific Journal of Rehabilitation Medicine*, *11*(3), 462-473. https://doi.org/10.32598/SJRM.11.3.10

Diamond, A. (2013). Executive functions. *Annual review of psychology, 64*, 135-168. https://doi.org/10.1146/annurev-psych-113011-143750

Durik, A. M., Vida, M., & Eccles, J. S. (2006). Task values and ability beliefs as predictors of high school literacy choices: A developmental analysis. *Journal of Educational Psychology, 98*(2), 382–393. https://doi.org/10.1037/0022-0663.98.2.382

Ebadi, S., & Rahimi, M. (2019). Mediating EFL learners' academic writing skills in online dynamic assessment using Google Docs. *Computer Assisted Language Learning, 32*(5–6), 527–555. https://doi.org/10.1080/09588221.2018.1527362

Friso-van den Bos, I., & van de Weijer-Bergsma, E. (2020). Classroom versus individual working memory assessment: Predicting academic achievement and the role of attention and response inhibition. *Memory, 28*(1), 70–82. https://doi.org/10.1080/09658211.2019.1682170

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

Gibby-Leversuch, R., Hartwell, B. K., & Wright, S. (2021). Dyslexia, literacy difficulties and the self-perceptions of children and young people: A systematic review. *Current Psychology, 40*, 5595–5612. https://doi.org/10.1007/s12144-019-00444-1

Godde, E., Bosse, M.L., & Bailly, G. (2020). A review of reading prosody acquisition and development. *Reading and Writing, 33*, 399–426. https://doi.org/10.1007/s11145-019-09968-1

Goswami, U. (2019). *Cognitive development and cognitive neuroscience: The learning brain*. Routledge. https://doi.org/10.4324/9781315684734

Grills, A. E., Fletcher, J. M., Vaughn, S., Barth, A., Denton, C. A., & Stuebing, K. K. (2014). Anxiety and response to reading intervention among first grade students. *Child & Youth Care Forum, 43*, 417–431. https://doi.org/10.1007/s10566-014-9244-3

Jeltova, I., Birney, D. P., Fredine, N., Jarvin, L., Sternberg, R. J., & Grigorenko, E. L. (2007). Dynamic assessment as a process-oriented assessment in educational settings. *Advances in Speech-Language Pathology*, *9*(4), 273–285. https://doi.org/10.1080/14417040701460390

Johann, V. E., Könen, T., & Karbach, J. (2020). The unique contribution of working memory, inhibition, cognitive flexibility, and intelligence to reading comprehension and reading speed. *Child Neuropsychology, 26*(3), 324–344. https://doi.org/10.1080/09297049.2019.1649381

Katzir, T., Kim, Y.-S. G., & Dotan, S. (2018). Reading self-concept and reading anxiety in second grade children: The roles of word reading, emergent literacy skills, working memory and gender. *Frontiers in Psychology, 9*, Article 1180. https://doi.org/10.3389/fpsyg.2018.01180

Kudo, M. F., Lussier, C. M., & Swanson, H. L. (2015). Reading disabilities in children: A selective meta-analysis of the cognitive literature. *Research in Developmental Disabilities, 40*, 51–62. https://doi.org/10.1016/j.ridd.2015.01.002

Lindeblad, E., Nilsson, S., Gustafson, S., & Svensson, I. (2019). Self-concepts and psychological health in children and adolescents with reading difficulties and the impact of assistive technology to compensate and facilitate reading ability. *Cogent Psychology, 6*(1), Article 1647601. https://doi.org/10.1080/23311908.2019.1647601

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

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

Medina, G. B. K., & Guimarães, S. R. K. (2021). Leitura na dislexia do desenvolvimento: o papel da consciência fonêmica e das funções executivas [Reading in developmental dyslexia: The role of phonemic awareness and executive functions]. *Estudos De Psicologia (Campinas)*, *38*. https://doi.org/10.1590/1982-0275202138e180178

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

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,* Article 173. https://doi.org/10.3389/fpsyg.2017.00173

Nazari, B. (2012). Teach-to-test instruction of dynamic assessment: A critical overview. *Bellaterra Journal of Teaching and Learning Language and Literature, 5*(4), 56-68. https://doi.org/10.5565/rev/jtl3.468

Nicholas, M., & Rouse, E. (2021). Learning to read: Where should early childhood educators begin? *Literacy, 55*(1), 3–13. https://doi.org/10.1111/lit.12229

O'Brien, G., & Yeatman, J. D. (2021). Bridging sensory and language theories of dyslexia: Toward a multifactorial model. *Developmental Science, 24*(3), Article e13039. https://doi.org/10.1111/desc.13039

Passig, D., Tzuriel, D., & Eshel-Kedmi, G. (2016). Improving children's cognitive modifiability by dynamic assessment in 3D immersive virtual reality environments. *Computers & Education, 95*, 296-308. https://doi.org/10.1016/j.compedu.2016.01.009

Peng, P., Barnes, M., Wang, C., Wang, W., Li, S., Swanson, H. L., Dardick, W., & Tao, S. (2018). A meta-analysis on the relation between reading and working memory. *Psychological Bulletin, 144*(1), 48–76. https://doi.org/10.1037/bul0000124

Petersen, D. B., Allen, M. M., & Spencer, T. D. (2016). 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

Petersen, D. B., Gragg, S. L., & Spencer, T. D. (2018). Predicting reading difficulties 6 years into the future: dynamic assessment reduces bias and increases classification accuracy. *Language Speech and Hearing Services in Schools, 49*(4), 875–888. https://doi.org/10.1044/2018_lshss-dyslc-18-0021

Poehner, M. E., & Lantolf, J. P. (2013). Bringing the ZPD into the equation: Capturing L2 development during Computerized Dynamic Assessment (C-DA). *Language Teaching Research, 17*(3), 323-342. https://doi.org/10.1177/1362168813482935

Puhan, G., Boughton, K. A., & Kim, S. (2007). Examining differences in examinee performance in paper and pencil and computerized testing. *Journal of Technology, Learning and Assessment, 6*(3), 4-20. https://bit.ly/3rR5NPu

Resing, W. C. M. (2000). Assessing the learning potential for inductive reasoning (LIR) in young children. In C. Lidz & J. G. Elliott (Eds.), *Dynamic assessment: Prevailing models and applications* (pp. 229–262). Elsevier Science.

Resing, W. C. M. (2013). Dynamic testing and individualised instruction: helpful in cognitive education? *Journal of Cognitive Education and Psychology*, *12*(1), 81–95. https://doi.org/10.1891/1945-8959.12.1.81

Resing, W. C. M., Bleichrodt, N., Drenth, P. J. D., & Zaal, J. N. (2012). *Handleiding verantwoording RAKIT-2 Deel 2 Normen, betrouwbaarheid, validiteit en interpretative* [Manual RAKIT-2 Part 2 Norms, reliability, validity and interpretation]. Pearson.

Resing, W. C. M., Elliott, J. G., & Vogelaar, B. (2020). Assessing potential for learning in schoolchildren. In *Oxford Research Encyclopedia of Education*. Oxford University Press. https://doi.org/10.1093/acrefore/9780190264093.013.943

Ribner, A. D., Willoughby, M. T., Blair, C. B., & The Family Life Project Key Investigators. (2017). Executive function buffers the association between early math and later academic skills. *Frontiers in Psychology, 8,* Article 869. https://doi.org/10.3389/fpsyg.2017.00869

Sadasivan, A., Rucklidge, J. J., Gillon, G., & Kapur, M. (2012). Role of executive functions in improving reading accuracy in Indian children with reading disorder, comparing two types of intervention. *Journal of Special Needs Education, 2*, 9-25. https://bit.ly/3twvjdp

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

Shareef, Z., Östberg, P., & Hedenius, M. (2018). Verbal fluency in relation to reading ability in students with and without dyslexia. *Applied Psycholinguistics, 40*(2), 445–472. https://doi.org/10.1017/s0142716418000644

Smith-Spark, J. H., Henry, L. A., Messer, D., & Zięcik, A. P. (2017). Verbal and non-verbal fluency in adults with developmental dyslexia: Phonological processing or executive control problems? *Dyslexia, 23*(3), 234–250. https://doi.org/10.1002/dys.1558

Snowling, M. J. (2013). 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

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*(6), 643-661. https://doi.org/10.1037/h0054651

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 dyslexia diagnostics and intervention version 3.0]. Nederlands kwaliteitsinstituut Dyslexie (NKD). https://bit.ly/3McGsX2

Vadasy, P. F., Sanders. E. A., & Cartwright, K. B. (2022). Cognitive flexibility in beginning decoding and encoding. *Journal of Education for Students Placed at Risk, 28*(4), 412-438. https://doi.org/10.1080/10824669.2022.2098132

Van der Elst, W., Van Boxtel, M. P. J., Van Breukelen, G. J. P., & Jolles, J. (2008). Detecting the significance of changes in performance on the Stroop Color-Word Test, Rey's Verbal Learning Test, and the Letter Digit Substitution Test: The regression-based change approach. *Journal of the International Neuropsychological Society, 14*(1), 71–80. https://doi.org/10.1017/S1355617708080028

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., Resing, W. C. M., Stad, F. E., & Sweijen, S. W. (2019). Is planning related to dynamic testing outcomes? Investigating the potential for learning of gifted and average-ability children. *Acta Psychologica, 196*, 87–95. https://doi.org/10.1016/j.actpsy.2019.04.004

Vygotsky, L. S. (1978). *Mind in Society: The development of higher psychological processes*. Harvard University Press. https://doi.org/10.2307/j.ctvjf9vz4

Wackerle-Hollman, A. K., Schmitt, B. A., Bradfield, T. A., Rodriguez, M. C., & McConnell, S. R. (2015). Redefining individual growth and development indicators. *Journal of Learning Disabilities, 48*(5), 495–510. https://doi.org/10.1177/0022219413510181

Wechsler, D. (2014). *Wechsler Intelligence Scale for children* (5th ed.). Pearson. https://bit.ly/46VZ8Cm

Zuppardo, L., Rodríguez Fuentes, A. R., Pirrone, C., & Serrano, F. (2020). Las repercusiones de la dislexia en la autoestima, en el comportamiento socioemocional y en la ansiedad en escolares [The repercussions of dyslexia on self-esteem, socio-emotional behavior and anxiety in schoolchildren]. *Psicología Educativa, 26*(2), 175–183. https://doi.org/10.5093/psed2020a4