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Predictors of Reading and Spelling Difficulties in Italian Children: Specific Language and General Cognitive Skills

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Abstract

This study investigated the role of domain-specific and domain-general factors in predicting early literacy skills in Italian children. A sample of 239 first-grade students was evaluated using a broad neuropsychological battery to assess their cognitive skills. The results showed that phonological awareness, rapid automatized naming, speed of processing, and attentional control all played a role in predicting reading and writing abilities. These findings support the importance of considering not just domain-specific language skills, but also domain-general cognitive skills when identifying children at risk of difficulties in reading and writing. The study supports the adoption of a multifactorial-probabilistic model to accurately diagnose specific learning disorders.

Keywords

screening, predictors, early identification, reading, spelling

Literacy skills play a crucial role in modern societies, strongly influencing not only academic and professional success but also broader life outcomes (Carneiro & Gordon, 2013; Pape et al., 2011). Yet, recent data show that a wide share of the school-age population does not master reading and writing successfully. In Italy, even though the majority of the researchers found the prevalence of a learning disorder to be 2.5% to 5% of the school-aged population (e.g., Barbiero et al., 2012, 2019), learning difficulties seemed to affect a wider percentage of children, with 10%–15% of regularly schooled children classified as "poor readers" or "poor writers." This is a critical issue as children with low literacy skills are at high risk of poor academic performance, as well as mental health, behavioral, and social difficulties (Ghisi et al., 2016; Livingston et al., 2018).

Given the importance of addressing poor literacy performance, early screening of children at risk of developing learning difficulties is crucial. Effective screening protocols enable teachers and clinicians to implement personalized training for each child (National Early Literacy Panel, 2008). In Italy, only recently has the need for tools and protocols suitable for the early identification of Italian-speaking children with learning difficulties received targeted attention (Associazione italiana dislessia, 2009). Several more or less extensive screening batteries (e.g., Fanari & Orsolini, 2014; Marotta et al., 2008; Stella & Savelli, 2011) or observational questionnaires have been implemented in the last two decades. The late formulation of effective and validated screening tools is partly due to the nebulousness surrounding the aetiology of the learning disorders.

Reading Predictors

Domain-Specific Predictors

The early screening protocols were mainly based on a theoretical model that posits phonology at the base of reading success and failure (Griffiths & Snowling, 2001; Vellutino et al., 2004). Research has also recognized the critical role of phonological development in acquiring written language (Hulme et al., 2015; Snowling et al., 2019). According to these researchers, reading descends from the increasingly automatic identification of groups of linguistic units (i.e., graphemes, syllables). Indeed, accumulating evidence suggests that different phonological structures influence the development of phonological awareness (Melby-Lervåg et al., 2012). For example, Snider (1995) noted: "Children become aware of larger linguistic units (words and syllables) before they become aware of smaller linguistic units (phonemes)" (p. 444). Thus, phonemic awareness is the last ability to develop, with onset-rime awareness serving as an

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intermediate stage (Konza, 2011). The causal link from phonological awareness to success in learning to read has been extensively discussed, with strong evidence supporting this relationship (Castles & Coltheart, 2004).

Phonological working memory is also a significant predictor of literacy difficulties (Baddeley, 2003; Gathercole & Baddeley, 1993). Deficits in phonological awareness and short-term memory can hinder the development of sublexical processes, which are crucial for literacy acquisition in alphabetic writing systems (Daucourt et al., 2018). It is widely recognized that children with dyslexia speaking different languages struggle with phonological awareness skills (Landerl et al., 2013). For example, Ziegler et al (2010) analyzed the predictive role of phonological awareness across different orthographic systems and found that its impact varies with orthographic depth. Thus, in transparent orthographies like Italian, the predictive role of phonological awareness is lower than in opaque orthographies like English. Moreover, its predictive role diminishes after the first year of schooling in transparent orthographies.

Landerl et al (2019) found that rapid automatized naming (RAN), rather than phonological awareness, consistently predicts reading fluency across different orthographies. Moreover, other studies have found that RAN is a predictor of not only reading speed but also reading accuracy development (Kirby et al., 2010; Swanson et al., 2003). Further, RAN has been shown to be related to reading comprehension (Arnell et al., 2009; Johnston & Kirby, 2006), indicating its broad role in reading (Araújo & Faísca, 2019; Huschka et al., 2021).

Domain-General Predictors

While the roles of phonological awareness and RAN are well documented (Manolitsis et al., 2009; Norton & Wolf, 2012; Schatschneider et al., 2004; Schmitterer & Schroeder, 2019; Torppa et al., 2007; Wolff, 2014), other cognitive skills also contribute significantly to early literacy (Burgoyne et al., 2019; Moll et al., 2014, 2016; Pasqualotto et al., 2024; Varvara et al., 2014). Efficient text decoding requires visual attention distribution on the page to select appropriate graphemes while inhibiting orthographic competitors (Grainger et al., 2016; Lallier et al., 2013; Vidyasagar, 2013). Thus, inhibition is crucial for selecting the correct phoneme for a grapheme and suppressing phonological competitors (Frisson et al., 2014; Ziegler et al., 2014). Cognitive flexibility is also important for building cross-modal connections and switching between various dimensions of written content such as phonology, morphology, semantics, and syntax (Blair & Razza, 2007; Colè et al., 2014; Georgiou & Das, 2016; Peng et al., 2019; St Clair-Thompson & Gathercole, 2006).

Longitudinal studies have shown that slow auditory attentional shifting in pre-readers at risk for dyslexia significantly predicts future reading impairments in primary school (Blockmans et al., 2023; Boets et al., 2008, 2011; Franceschini et al., 2012). For instance, Franceschini et al (2012) demonstrated that early attentional abilities, measured before reading acquisition, can predict later reading skills. Recent research further highlights the role of auditory attentional shifting, showing that it influences the learning trajectories of symbol-speech sound correspondence and modulates neural sound tracking in children with and without dyslexia (Guerra et al., 2024). Indeed, impaired attentional control in dyslexia has been linked to greater deficits in reading fluency and reduced activation in the typical left-hemisphere phonological and orthographic reading networks (Chyl et al., 2021).

Additionally, some domain-general deficits related to cognitive control are associated with developmental dyslexia (Pasqualotto & Venuti, 2020; Varvara et al., 2014), especially deficits in visual attention (for recent reviews, see Tang et al., 2023; Valdois, 2022). Such deficits can affect letter identification, letter position coding, processing of letter strings in parallel, and programming of eye movements, all of which are necessary for developing automatic word recognition and reading skills. Beyond visual attention deficits, weaknesses in cognitive control, such as poor working memory or deficient inhibitory processes, have also been identified as associated with dyslexia (Johann et al., 2020; Morris & Lonigan, 2022; Peng et al., 2019.

However, some meta-analyses and systematic reviews suggest that domain-general cognitive skills do not predict reading skills beyond foundational literacy skills such as phonological processing and comprehension. For example, Quinn and Wagner (2018) found that while there were large correlations between cognitive components (such as working memory and processing speed) and decoding and linguistic comprehension, a direct pathway from these cognitive skills to reading was not supported. A recent meta-analytic review by Peng et al (2022) demonstrated that children with developmental disabilities (DD) showed deficits across processing speed, inhibition, switching, working memory, and visuospatial skills. However, this review also found that domain-general skills may make unique contributions to reading difficulties beyond decoding and language comprehension, but their influence is limited when foundational literacy skills are accounted for.

Spelling Predictors

Writing, specifically spelling, is a complex skill that relies on multiple cognitive processes (Brown & Ellis, 1994; Ellis, 2016). Similar to reading, it involves both domain-specific and domain-general cognitive abilities.

Domain-Specific Predictors

Phonological awareness is a critical domain-specific predictor for spelling. Numerous studies have demonstrated a strong relationship between phonological awareness and spelling skills (Galuschka et al., 2020; Moll et al., 2014).

For example, orthographic knowledge, involving understanding the conventions and rules of written language, significantly contributes to spelling accuracy (Apel, 2011; Ehri, 2014). Morphological awareness, the understanding of word structure and the ability to manipulate morphemes, is also essential for spelling skills (Grigorakis & Manolitsis, 2021).

Rapid automatized naming (RAN) has been extensively studied as a predictor of reading skills, but its role in spelling is also significant. RAN is an independent predictor of word spelling (Georgiou et al., 2012; Savage & Frederickson, 2006). Several studies indicate that RAN supports the development of orthographic representations of words, but its relationship with spelling varies across languages with different orthographic complexities (Georgiou et al., 2016; for a recent meta-analyses, see Chen et al., 2021). A study by Huschka et al (2021) on German children revealed that while RAN components like pause time and pause time consistency were significant predictors of reading fluency, they did not predict spelling performance, highlighting the complex nature of spelling development.

Domain-General Predictors

More domain-general cognitive functions, such as working memory, cognitive flexibility, and inhibitory control, are crucial predictors of spelling (Kim & Park, 2019). Working memory, in particular, is essential for holding and manipulating information during the spelling process (Swanson & Berninger, 1995; Vanderberg & Swanson, 2007). Studies have shown that working memory capacity is related to spelling performance (DeBono et al., 2012). Cognitive flexibility, the ability to switch between different tasks or mental processes, is important for spelling because it allows children to switch between different linguistic rules and apply them correctly (Berninger et al., 2008; Drijbooms et al., 2015; Quinlan et al., 2012). Inhibitory control, which is the ability to suppress irrelevant information and stay focused on a task, plays a significant role in filtering out inappropriate lexical representations at the word level, grammatical structures at the sentence level, and irrelevant ideas at the text level (Altemeier et al., 2008; Kellogg et al., 2013).

From this short review, it is evident that both domain-specific and domain-general cognitive skills play crucial roles in the development of reading and spelling abilities (Costa et al., 2018; Daucourt et al., 2018; Ruffini et al., 2024; Ziegler et al., 2020). However, the existing literature shows variability in how these predictors impact literacy outcomes across different languages and orthographies. Therefore, despite the wealth of research, there is still a need to explore these relationships in the context of the Italian language, which has been relatively understudied. The present study aimed to fill this cap and contribute to the literature on the relationship between reading and reading-related linguistic and cognitive skills, focusing on Italian, an understudied language. The study involved a sample of 239 Italian-speaking children from the Trentino area in northern Italy.

Aims and Hypotheses of the Current Study

The first aim was to determine whether poor readers and spellers exhibit significantly lower performance in phonological awareness, attentional control, and visual-auditory integration skills than their typically developing peers. To achieve this, we administered a large battery of standardized tests. We hypothesized that poor readers and spellers would show deficits not only in speech-sound processing skills (i.e., phonological awareness) and visual-to-phonological mapping (RAN) but also in attentional control capacities. We specifically predicted that these skills, measured during the first half of the first grade (T1), would effectively discriminate between "poor" and "typically developing" readers/spellers at the end of the first year (T2).

The second aim was to investigate the potential causal links between the cognitive skills assessed during T1 and literacy performance (reading and writing) at T2. Specifically, we were interested in the extent to which literacy skills depend on phonological awareness, rapid naming, and attentional control. We hypothesized that these cognitive skills measured at T1 would predict literacy outcomes at T2.

Methods

Participants

A total of 239 Italian first graders, aged from 5 years to 6 years and 11 months (mean age = 6 years and 3 months; *SD* = 5 months), of both sexes, who were enrolled in elementary public schools participated in the study. Children were recruited through three primary schools in Trentino's urban area. Parents and/or guardians of all the participants received a detailed explanation of the procedure of the study and provided a signed informed consent, in accordance with the Declaration of Helsinki.

All the children were native Italian speakers with normal or correct-to-normal vision and hearing abilities. The children's IQs were within the normal range (IQ > 85). Children with any psychological, neurological, or medical diagnoses, such as specific language impairment (SLI), attention-deficit/hyperactivity disorder (ADHD), autism spectrum disorder (ASD), epilepsy, or other relevant neurological and medical conditions were not included in the analysis. Notably, in Italy, the diagnosis of SLD can only be made starting at the end of second grade.

Exclusion criteria for participation in the study were the following: motor or cognitive impairment and children whose parents/guardians did not sign the consent form. As a result, 10 non-native Italian speakers, one student with intellectual disability, and three students whose parents/guardians did not sign the consent form were excluded from the final sample of 239 children.

Based on standardized scores obtained in the text reading task (Cornoldi & Colpo, 1998) and/or the writing task (Sartori et al., 1995) at T2, children were divided into two groups: "Poor" and "typically developing" (TD) (see Statistical Analysis below). The "Poor" group included children who scored lower than −1.5 *SD* from the expected value for their age and level of schooling in either or both tasks, resulting in 57 children in the "Poor" group. The "TD" group consisted of 172 children who did not meet this criterion.

Procedures

Children's reading-related predictors and the development of their reading skills were measured at two distinct time points (see Table 1). The first measurement (T1) occurred during the first half of the first grade, specifically in early January, after 3 months of formal schooling. During this period, all children were classified as emergent readers. The second measurement (T2) took place at the end of the academic year in June, by which time the children had transitioned to beginning readers. This allowed us to assess their reading abilities after receiving additional formal instruction and practice throughout the school year. Trained clinical psychologists administered the tests.

Most of the tests were administered individually, with the exception of the fluid intelligence, text comprehension, and writing (spelling) tasks, which were administered collectively. Tasks were administered in a pseudorandom manner (IQ, comprehension, and writing abilities were always assessed before the individual testing began). The individually administered tests were conducted in a 60-min session in a quiet room at the children's school, with breaks provided to avoid fatigue and ensure high-quality performance.

Tools

The assessment protocol included standardized cognitive-linguistic tests to evaluate IQ, literacy skills, visuo-spatial attention, and visual-motor integration skills (see Table 1 for an overview). Raw data from all tasks were converted to standardized scores (*z*-scores or standard scores) according to age and/or schooling, except for phonological awareness, which was expressed in percentiles.

A short description of the tests used at each time point is provided below.

T1

Colored Progressive Matrices. Fluid intelligence (Gf) was assessed using a nonverbal multiple-choice IQ test: the Raven's Colored Progressive Matrices (CPM; Raven, 2003). The CPM evaluates the ability to form perceptual relations and to problem solve by analogy, irrespective of culture, language, and formal schooling. The task was administered collectively, and the scores were converted using the normative data for collective administration (see Italian standardization of the booklet form; Belacchi et al., 2008). Test–retest reliability is typically reported as being between 0.80 and 0.90, indicating strong reliability. For instance, Cotton et al (2005) found an internal consistency of 0.89 ($p < .001$) and split-half reliability of 0.91 ($p < .001$) in their sample of primary-school children.

Test delle Campanelle Modificato. Visuo-spatial attention was measured through the Test delle Campanelle Modificato [Modified Bells Test] (Biancardi & Stoppa, 1997) barrage task. In this task, children are required to localize and quickly check the targets (i.e., images of bells) among distractors (i.e., familiar figures such as houses, horses). The stimuli are pseudo-randomly organized, and each sheet contained 35 targets.

Two types of *z*-scores are produced: the score given by the sum of the targets (bells) found in the first 30 s for each of the four sheets that compose the test (fast score), and the score obtained by counting the total number of targets found in 120 s (slow score). TCM shows good test–retest reliability, approximately 0.85 ($p < .01$), and internal consistency with values generally ranging from 0.75 ($p < .05$) to 0.85 ($p < .01$) (Biancardi & Stoppa, 1997).

Table 1. Study Design and Assessments.

Time point	Timing	Assessment focus	Tests administered
T1	January	Cognitive and reading predictors	CPM—Colored Progressive Matrices (Raven, 2003) TCM—Test delle Campanelle Modificato [Modified Bells Test] (Biancardi & Stoppa, 1997) VMI—Developmental Test of Visual-Motor Integration (Beery et al., 2010) PRCR-2—Prove di prerequisito per la Diagnosi delle Difficoltà di Lettura e di Scrittura [Tests of prerequisites for the diagnosis of difficulties in reading and writing] (Cornoldi et al., 2009)
T2	June	Literacy skills	Text Reading—Prove di lettura MT per la scuola elementare-2 [Reading tests for primary school] (Cornoldi & Colpo, 1998) Word Writing—DDE-2—Batteria per la valutazione della dislessia e disortografia evolutiva [Battery for the assessment of developmental reading and spelling disorders] (Sartori et al., 1995)

Developmental Test of Visual-Motor Integration. The Developmental Test of Visual-Motor Integration (VMI; Beery et al., 2010) was used to assess how children integrated their visual and motor skills. During this paper-and-pencil task, the child was asked to copy a sequence of geometric shapes of increasing difficulty. The untimed task has to be hand-scored by the examiner: each correct reproduction of a geometrical shape is scored as 1 point. The administration included two supplemental tests: Visual Perception—VP and Motor Coordination—MC, which investigated visual analysis/visual-spatial ability and motor coordination, respectively. The interrater reliability of 0.92 ($p < .01$), internal consistency of 0.96 ($p < .001$), and test–retest reliability of 0.89 ($p < .01$) demonstrate the strong psychometric properties of the measure (Beery et al., 2010).

Prove di Prerequisito per la Diagnosi delle Difficoltà di Lettura e di Scrittura. The Prove di Prerequisito per la Diagnosi delle Difficoltà di Lettura e di Scrittura [Tests of prerequisites for the diagnosis of difficulties in reading and writing] (PRCR-2; Cornoldi et al., 2009) is one of the most widely used Italian tests for assessing literacy skills predictors in children. The battery allows for examining specific predictors of literacy abilities and the partial processes involved in reading/writing activities. The test investigates six areas: visual analysis, scanning from left to right, auditory discrimination and rhythm, sequential auditory memory and auditory fusion, visuo-auditory integration, and visual globality. In the current study, we examined the following areas:
Visual Analysis

- *Test of the "semi-circles."* The task consists of three series of 10 cards on which are represented graphic symbols that vary in orientation and structure. The child is asked to look carefully at one item at a time, because after a few seconds the item will be covered, and they will have to reproduce it by drawing it on the response sheet that was given to them before.
- *Letter recognition.* This test assesses visual analysis and spatial orientation. The child is asked to identify and check the letter equal to the target letter among a set of distractors.

Serial Scanning From Left to Right

- *Naming of objects (RAN of objects).* This test evaluates the ability to move efficiently from left to right under optimal conditions of stimulus distinctiveness, linguistic competence, and the speed of naming objects. Drawings of 30 different objects are presented in rows of six. The child must name the objects following the direction from left to right and top to bottom. An error score, corresponding to the number of errors (omissions and inversions), and a speed score, corresponding to the time (in seconds) required to complete the test, are provided.
- *Naming of intertwined objects.* Using the objects from the RAN of objects subtest, this test presents the objects in a slightly overlapping, intertwined format. It is a timed subtest that evaluates the correctness, the order of the fixations, and the visual-perceptual ability to distinguish the figure from the context-background. Error scores and speed scores are recorded.
- *Naming of pointed objects.* This task uses the same objects as the previous subtests but arranged in two lines with dots above them. It measures the measures the child's ability to fixate on specific targets, while ignoring the distractors. The child is asked to name the targets (eight for each line), which are the objects that are placed under the dot. An error score and a speed score are assigned.
- *Visual search of two letters "B" and "L."* The barrage test consists of a matrix of 300 capital letters in which the target letters "B" and "L" are randomly distributed. The child is asked to cross out all the target letters they encounter, proceeding neatly from left to right and from top to bottom, without ever going back. The total number of errors and the time in seconds are taken into account.
- *Visual search of the letter sequence "TOC."* The test consists of a matrix of capital letters in which the TOC sequence appears several times in random order. The total number of errors and the time in seconds are taken into account.

Auditory Discrimination and Rhythm

- *Nonword repetition.* The test involves phonemic discrimination and short-term memory of phonemes and meaningless words (i.e., nonwords). The child is instructed to listen carefully to the meaningless word spoken by the examiner and to repeat the stimuli exactly as they heard it, without modifying it in any way. The subtest is untimed. All the nonwords are repeated one by one.
- *Phonetic segmentation test.* Phonological awareness was tested using an untimed measure that assesses the child's ability to segment words into their component sounds. The test consists of three parts: (a) identification of the first and last phoneme from a list of 10 pronounced words; (b) the score (Part 1 and Part 2); and (c) the proper phonetic segmentation in which the examiner orally presents words of three to four phonemes and the child is required to segment the word by pronouncing the individual phonemes in the exact sequence (Part 3).

The psychometric characteristics of PRCR-2 (Cornoldi et al., 2009) are adequate, with good reliability and concurrent and predictive validity coefficients. Specifically, reliability coefficients range between 0.61 ($p < .05$) and 0.89 ($p < .001$), and construct validity coefficients range between 0.19 ($p < .05$) and 0.35 ($p < .01$).

T2

At the second assessment time point, children' literacy skills were evaluated using two different tasks:

Text Reading. Prove di Lettura MT per la Scuola Elementare-2 [Reading tests for primary school] (MT-2; Cornoldi & Colpo, 1998). This timed age-standardized text-reading task was used to measure ecological context reading. Participants are asked to read aloud—as fast as accurately as possible—a short text passage of 140 syllables. A text reading score is indexed by calculating the mean between the accuracy and fluency scores.

Word Writing. Batteria per la valutazione della dislessia e disortografia evolutive [Battery for the assessment of developmental reading and spelling disorders] (DDE-2; Sartori et al., 1995). Children are required to write (without any time limits) 48 words that vary in terms of orthographic complexity and frequency of use. This spelling task provides correctness scores, expressed as number of correct responses, in writing words.

Both the MT-2 and the DDE-2 batteries are widely recognized as gold-standard tools for assessing reading and spelling skills in the Italian population, as supported by the Consensus Conference for Learning Disorders (Associazione italiana dislessia, 2009; Lorusso et al., 2014). Both tools exhibit good test–retest reliability, with Spearman's Rho values of .56 ($p < .05$) and .97 ($p < .001$) for the MT-2 and DDE-2, respectively. Additionally, they demonstrate adequate construct validity, with Spearman's Rho values of .24 ($p < .05$) for the MT-2 and .39 ($p < .05$) for the DDE-2.

Results

Statistical Analysis

Statistical analysis was conducted using the SPSS (Statistical Package for Social Sciences; IBM), version 16.0. Based on the standardized scores obtained in the text reading task (Cornoldi & Colpo, 1998) and/or the writing task (Sartori et al., 1995) at T2 (i.e., at the end of the first year of primary school), the children were divided into two subgroups. The first group, named "Poor," included children who scored lower than −1.5 *SD* from the expected value for their age and level of schooling in either or both tasks ($n = 57$). Children who did not meet this criterion were assigned to the "typically developing" (TD) group ($n = 172$).

Descriptive statistics of the participants' background were presented in Table 2. The sample was adequately homogeneous in terms of six (112 males and 117 females) and age. Specifically, 25 females and 32 males were included in the "Poor" group, while 92 females and 80 males were included in the TD group. There were no significant differences between the two groups in terms of age ($p = .89$) and fluid intelligence (age: $p = .89$; IQ: $p = .16$). However, the literacy performance of the two groups differed significantly in both the text reading task and the writing test.

The following analyses were conducted to further explore the cognitive deficits at T1 in future poor readers or spellers and to predict reading abilities at T2 based on reading-related cognitive skills measured at T1. These analyses include *t*-tests for unpaired samples and hierarchical regression analyses, respectively, to identify key predictors and understand the development of literacy skills.

Cognitive Deficits at T1 in Future Poor Readers or Spellers

Using several *t*-tests for unpaired samples, differences in the performance on the tests administered at T1 (i.e., literacy predictors) between "Poor" and TD children were analyzed (see Table 3). The standardized scores (*z*-scores) were corrected according to Bonferroni's method for multiple comparisons (significance at <.05).

The results highlighted which tests played a predominant role in distinguishing between "Poor" and TD readers/spellers. Specifically, the "Poor" group performed significantly lower than the TD group in the following subtests of PRCR-2: *Phonetic segmentation* ("Poor" $M = -0.42$, $SD = 0.79$;

Table 2. Descriptive Statistics of the Two Groups.

	"Poor"		TD			
	M	*SD*	*M*	*SD*	*p*	*g*
Sex (F–M)	25–32		92–80		.32[a]	0.30
Age (years)	6.5	0.32	6.45	0.47	.89[b]	0.11
IQ (standard scores)	89.15	15.24	96.05	19.33	.16[b]	0.37
Text reading (z-scores)	−2.17	0.52	−0.04	0.18	.001[b]*	7.05
Word writing (z-scores)	−1.98	0.73	0.01	0.44	.02[b]*	3.77

Note. Means (*SD*) for the two groups ("Poor": $n = 57$; TD: $n = 172$) and effect size (Hedges' *g*) of the differences between groups. Children who obtained a score in the reading or writing tasks lower than −1.5 *SD* compared to the expected value for the same age and level of schooling were included in the "Poor" group. Children who did not meet the criterion were assigned to the TD group.
[a]χ^2-score, [b] *F*-score.
*Significance at $\alpha = .05$.

Table 3. Performance at T1 for "Poor" and TD Children.

		"Poor"		TD			
		M	*SD*	*M*	*SD*	*p*	*g*
PRCR-2	Semi-circles[a]	−0.64	2.13	0.09	2.15	.31	0.34
	Letter recognition[a]	−2.01	1.15	−0.87	1.95	.45	0.63
	Nonword repetition[a]	−1.87	0.81	−0.01	0.93	.04*	2.06
	Phonetic segmentation[a]	−0.42	0.79	0.98	0.45	.04*	2.52
	Naming of intertwined objects—Accuracy[a]	−1.04	0.55	−0.89	0.62	.58	0.25
	Naming of intertwined objects—Speed[a]	−5.15	1.58	−0.44	1.05	.03*	3.91
	Naming of pointed objects—Accuracy[a]	−1.47	0.9	−0.05	0.45	.03*	2.39
	Naming of pointed objects—Speed[a]	−0.73	1.16	−0.25	1.12	.09	0.42
	Visual search of two letters[a]	−0.15	1.34	0.05	2.01	.91	0.11
	Visual search of a sequence of letters[a]	−1.04	1.07	1.01	1.62	.89	0.69
TCM	Fast[a]	−1.17	1.14	−0.01	1.25	.14	0.94
	Slow[a]	−1.88	1.52	−0.11	1.26	.07	1.33
VMI	VMI[b]	94.51	12.5	106.02	19.15	.97	0.64
	CM[b]	119	14.02	117.35	17.03	1.25	0.10
	PV[b]	104.1	13.52	118.02	18.97	1.14	0.78

Note. Performance obtained by "Poor" and TD children in the tests performed at T1. Performance is expressed as standardized scores based on normative data: [a] z-score ($M=0$; $SD=\pm1$); [b] standard score ($M=100$; $SD=\pm15$). Hedges' *g* and Bonferroni corrected *p* values (*significance at <.05) between groups.

TD = 0.98, $SD=0.45$, $p=.04$); *Nonword repetition* ("Poor" $M=-1.87$, $SD=0.81$; TD = −0.01, $SD=0.93$; $p=.04$); the Speed score of the *Naming of intertwined objects* ("Poor" $M=-5.15$, $SD=1.58$; TD = −0.44, $SD=1.05$, $p=.03$); the Accuracy score of the *Naming of pointed objects* ("Poor" $M=-1.47$, $SD=0.9$; TD = −0.05, $SD=0.45$, $p=.03$). In addition, there was a trend in the score for the speed of this test ("Poor" $M=-0.73$, $SD=1.16$; TD = −0.25, $SD=1.12$, $p=.09$). Indeed, the nonword repetition and the naming tasks require higher attention load (i.e., attentional control) than the phonetic segmentation task as they encompass the processes involved in active memory (*Nonword repetition*) and shifting between selective and divided attention (*Naming*).

Furthermore, although there was no statistically significant difference between the two groups, the results revealed a trend toward significance in the slow score of the barrage task (TCM_accuracy) ("Poor" $M=-1.88$, $SD=0.52$; TD = −0.11, $SD=1.26$, $p=.07$).

Predicting Reading at T2 From Reading-Related Cognitive Skills at T1

Since we demonstrated that "Poor" children at T1 already showed deficits in attentional control and phonological awareness skills, we further explored the possible link between children's performance in the cognitive tasks administered at T1 (i.e., mid-first year) and the literacy skills at T2 (i.e., the end of the first grade) across our entire sample of children ($N=239$), regardless of our a priori group classification of being at risk of a reading/spelling disorder.

Two separate hierarchical regression analyses were performed of each dependent variable (text reading and word writing) to investigate whether cognitive skills measured at T1 influenced later reading and spelling performances.

In the first step, age and IQ were included to control for possible confounding effects. In the second step, *Nonword repetition* and *Phonetic segmentation* were added. These two subtests of the PRCR-2 were introduced with the aim to detect the contribution to later literacy performance of the phonological awareness skills. The *Nonword repetition* task is also a short-term memory measure. In the third step, *Naming of intertwined objects* and *Naming of pointed object* were added to assess the effects of rapid lexical retrieval, processing speed, and the ability to separate target objects from distractors in challenging perceptual situations (i.e., overlapping images of objects).

The two hierarchical regression analyses, using the scores of the PRCR-2 as the independent variables and text reading and word writing as the dependent variables, led to the following results (see Table 4). For text reading, none of the demographic variables significantly predicted reading performance at T2, $F(2, 236)=2.011$, $p=.471$, $r^2=.009$. This indicates that controlling for gender and IQ did not alter the relationships between the variables of interest. Phonological awareness skills at T1 uniquely explained 9% of the variance in text reading, $F(4, 234)=4.754$, $p<.001$, $\Delta R^2=.101$. The change in R^2 was significant, $F(1, 234)=15.86$, $p<.001$. Specifically, performance on the *Nonword repetition* subtest made a greater contribution to the prediction ($p=.001$) than the *Phonetic segmentation* task ($p=.038$). Adding the scores on *Naming of intertwined objects* and *Naming of pointed objects* to the regression model explained an additional 25% of the variance, $F(6, 232)=9.573$, $p<.001$, $\Delta R^2=.149$; this change in R^2 was significant, $F(2, 232)=12.471$, $p<.01$. Specifically, both subtests significantly contributed to the model ($p=.045$ and $p<.001$, respectively).

Table 4. Hierarchical Regression Analysis.

	Model 1		Model 2		Model 3	
	β	*p*	β	*p*	β	*p*
Text reading						
Age	−.166	.038	−.131	.074	−.111	.132
IQ	.008	.922	.012	.879	−.004	.952
Nonword repetition			.321	.000	.318	.001
Phonetic segmentation			.215	.011	.166	.038
Naming of intertwined objects					.178	.045
Naming of pointed objects					.344	.000
DF model	236		234		232	
F-value ANOVA (vs. null model)	2.05		4.75*		9.57**	
R^2 (vs. null model)	.009		.123		.248	
F-value ANOVA (vs. previous model)	2.28		15.86***		12.47***	
ΔR^2 (vs. previous model)	.008		.101		.149	
Word reading						
Age	−.055	.515	−.098	.145	−.080	.221
IQ	−.031	.716	−.022	.733	−.014	.830
Nonword repetition			.177	.008	.170	.010
Phonetic segmentation			.619	.000	.667	.006
Naming of intertwined objects					.109	.135
Naming of pointed objects					.121	.009
DF model	236		234		232	
F-value ANOVA (vs. null model)	.66		6.57**		16.89***	
R^2 (vs. null model)	.013		.114		.163	
F-value ANOVA (vs. previous model)	.66		17.57**		4.91**	
ΔR^2 (vs. previous model)	.013		.272		.035	

Note. Summary of three steps, fixed entry, hierarchical regression analysis (on the entire sample $N = 239$) for variables predicting the performance in text reading and word writing at T2. Model 1 controls for participants' age and IQ; Model 2 adds performance in tasks assessing phonological awareness at T1 (i.e., nonword repetition and phonetic segmentation); Model 3 adds performance in naming/speed of processing (i.e., naming of intertwined and naming of pointed objects).
$^*p < .05$. $^{**}p < .01$. $^{***}p < .001$.

For word writing, the regression analyses showed that IQ and age, introduced as control variables in the first step, accounted for a nonsignificant proportion of the explained variance, $F(2, 236) = 0.661$, $p = .851$, $r^2 = .009$. Phonological awareness skills at T1 explained 11% of variance, $F(4, 234) = 6.572$, $p < .001$, $\Delta R^2 = .272$, and this model provided a better fit of the data, $F(1, 234) = 17.574$, $p < .001$. In particular, both scores contributed equally to the prediction (*Phonetic segmentation*: $p = .006$; *Nonword repetition*: $p = .010$). Finally, the addition to the regression model of the scores in the tests assessing naming and attentional capacities explained an additional 16% of variance, $F(6, 232) = 16.892$, $p < .001$, $\Delta R^2 = .035$. This change in R^2 was significant, $F(2, 232) = 4.92$, $p < .01$. Important, only performance on the *Naming of pointed objects* test made a significant contribution to the prediction ($p = .009$), whereas performance on *Naming of intertwined objects* did not ($p = .135$).

These results indicate that in novice readers, the ability to read and write efficiently depends on the ability to manipulate sounds of the language, rapidly access the lexicon, and flexibly allocate attention (i.e., processing speed) that the child exhibited one year earlier.

Discussion

Learning to read is a complex process that is accomplished earlier and more easily in transparent orthographies, such as Italian, with highly consistent letter-sound correspondences compared to opaque orthographies characterized by a high percentage of irregular and inconsistent spellings (Seymour, 2005; Ziegler & Goswami, 2005). Since the level of orthographic transparency has been demonstrated to influence the acquisition of the written language and to modulate the expression of the learning disorders, in this study we investigated which early language and cognitive markers better discriminate between poor readers/spellers and typically developing peers. For this reason, two groups of children were formed on the basis of their performance on text reading and writing tasks at the end of first grade. Additionally, we examined the existence of specific predictive paths between reading-related capacities and literacy skills among Italian-speaking children at T1.

In line with existing studies on literacy predictors (Lyytinen et al., 2017; Schatschneider et al., 2004; Torppa et al., 2010), our findings revealed a consistent pattern of domain-specific deficits in children who were later identified as poor readers/spellers. In particular, typically developing children outperformed "Poor" children on two tasks assessing phonological awareness skills: *Phonetic segmentation* and *Nonword repetition*. Notably, the *Nonword repetition* test also involves a high load of executive resources since it requires an efficient mechanism of short-term memory of phonemes and meaningless words. We also demonstrated that "Poor" children in Grade 1 already showed a deficit in visual-to-phonological mapping skills (RAN), as well as serial visual search and visuospatial attentional control at T1. Specifically, future poor readers and spellers performed significantly lower on the *Naming of intertwined objects* and *Naming of pointed objects* tasks administered at the beginning of formal literacy instruction. These findings indicated that not only language-specific but also domain-general cognitive abilities were impaired prior to the development of inefficient literacy skills. Moreover, the causal role of these skills in emerging literacy abilities was confirmed by the results of the multiple regression analysis run on the entire sample, regardless of any a priori classification of the future difficulties in reading and writing. Both performance on phonological tasks (*Phonetic segmentation* and *Nonword repetition*) and tasks requiring efficient attentional control mechanisms was found to be related to the onset of literacy difficulties. Interestingly, the skills related to the rapid and efficient orienting of attention while inhibiting distractors (as assessed by the *Naming of intertwined objects* and *Naming of pointed objects* tasks) appeared to be the crucial ones in predicting performance on the literacy tasks, whereas the mere naming task (*RAN of objects*) was not significant. In fact, the analysis of Step 1 (phonological skills) and Step 2 (naming and attentional control) of the regression models revealed a fundamental result: after accounting for the effect of phonological skills on future reading and writing abilities (9% and 11% of the variance, respectively), attentional control variables explained a significantly larger portion of the variance in future reading skills (25%) compared to phonological skills. Additionally, they explained a similar portion of the variance in future writing skills (16%). These results confirm recent longitudinal studies suggesting the importance of domain-general mechanisms, particularly attentional control, as predictors for future literacy skills (Burgoyne et al., 2019; Franceschini et al., 2012; Peng et al., 2019; Tobia & Marzocchi, 2014).

Moreover, the presence of risk factors common to reading and spelling disorders is in line with what was introduced by the *Diagnostic and Statistical Manual of Mental Disorders*, fifth edition (DSM-5A; American Psychiatric Association, 2013), which eliminated distinct labels for each type of learning disorder in favor of a single diagnostic category called specific learning disorder (SLD). This multidimensional approach emphasizes the existence of more general dimensions that are transversal to different diagnostic categories, particularly dyslexia and dysorthographia. Recognizing the role of other cognitive factors in literacy acquisition is consistent with a growing number of studies showing higher global deficits in higher-order cognitive mechanisms in individuals with reading and spelling difficulties, particularly when there is a deficit in decoding (Lallier et al., 2013; Menghini et al., 2010; Moll et al., 2016; Peterson & Pennington, 2012; Varvara et al., 2014).

Literacy skills involve numerous processes, making it difficult to identify a single indicator that predicts the onset of an SLD in isolation. As stated by Rakhlin et al (2014): "Despite their fundamental role, phonological skills are clearly not sufficient for the development of fluent reading and accurate spelling" (p. 2).

In conclusion, adopting a multifactorial probabilistic model of SLD does not diminish the fundamental role played by domain-specific deficits in the aetiology of this disorder, but rather provides the opportunity to develop and validate effective educational curricula and intervention protocols. Understanding how at-risk children's early literacy capacities develop in each language and the factors explaining this development is crucial for clinicians and educators by providing insights into effective reading readiness programs (Ziegler et al., 2020).

Limitations

The following limitations of the current study bear mentioning. First, the assessment battery administered at T2 was limited to two tasks (i.e., text reading and word writing). A more in-depth characterization of the reading and spelling profile of the participants would require other standardized tests. However, our assumption was that text reading should be considered the most ecologically valid task, since it not only requires word-level decoding and lexical strategies but also semantic and syntactic processes.

Second, a major limitation of the study was that cognitive predictors were assessed only once at study onset. This design choice precluded the identification of potential interactive relations between cognitive skills and reading development over time. Longitudinal data would provide a more dynamic understanding of how these predictors influence literacy acquisition.

Finally, the generalizability of the results is subject to certain limitations since our sample comprised only Italian-speaking first graders. Therefore, our findings can be generalized specifically to the language under investigation and, possibly, to other languages with similar consistent orthography. Although we hypothesize that our findings may be generalized to text reading in different orthographies, the influence of each predictor would likely vary with the transparency of the alphabetic system.

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Consent to Participate

Informed consent was obtained by parents prior to participation to the study.

Consent for Publication

Parents provided written informed consent for the publication of any associated data and accompanying images.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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.

Ethical Approval

The University of Trento Ethics Committee approved the study, and the entire research was carried out in accordance with the principles of the Declaration of Helsinki.

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References

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

American Psychiatric Association, D. S. M. T. F., & American Psychiatric Association, D. S. (2013). *Diagnostic and statistical manual of mental disorders: DSM-5* (vol. 5, No. 5). Washington, DC: American psychiatric association.

Apel, K. (2011). What is orthographic knowledge? *Language, Speech, and Hearing Services in Schools*, *42*(4), 592–603. https://doi.org/10.1044/0161-1461(2011/10-0085

Araújo, S., & Faísca, L. (2019). A meta-analytic review of naming-speed deficits in developmental dyslexia. *Scientific Studies of Reading*, *23*(5), 349–68. https://doi.org/10.1080/10888438.2019.1572758

Arnell, K. M., Joanisse, M. F., Klein, R. M., Busseri, M. A., & Tannock, R. (2009). Decomposing the relation between rapid automatized naming (RAN) and reading ability. *Canadian Journal of Experimental Psychology/Revue Canadienne de Psychologie Expérimentale*, *63*(3), 173–84. https://doi.org/10.1037/a0015721

Associazione italiana dislessia. (2009). *Disturbi evolutivi specifici di apprendimento. Raccomandazioni per la pratica clinica di dislessia, disortografia, disgrafia e discalculia*. Edizioni Erickson.

Baddeley, A. (2003). Working memory and language: An overview. *Journal of Communication Disorders*, *36*, 189–208. https://doi.org/10.1016/S0021-9924(03)00019-4

Barbiero, C., Lonciari, I., Montico, M., Monasta, L., Penge, R., Vio, C., Tressoldi, P. E., Ferluga, V., Bigoni, A., & Tullio, A. (2012). *The submerged dyslexia iceberg: How many school children are not diagnosed? Results from an Italian study*. *PLOS ONE*, *7*(10), e48082. https://doi.org/10.1371/journal.pone.0048082

Barbiero, C., Montico, M., Lonciari, I., Monasta, L., Penge, R., Vio, C., Tressoldi, P. E., Carrozzi, M., De Petris, A., & De Cagno, A. G. (2019). The lost children: The underdiagnosis of dyslexia in Italy. A cross-sectional national study. *PLoS One*, *14*(1), e0210448. https://doi.org/10.1371/journal.pone.0210448

Beery, K. E., Buktenica, N. A., & Beery, N. A. (2010). *The Beery-Buktenica Developmental test of visual-motor integration: Administration, scoring, and teaching manual* (6th ed.). Pearson.

Belacchi, C., Scalisi, T. G., Cannoni, E., & Cornoldi, C. (2008). *CPM—Coloured progressive matrices. Standardizzazione italiana*. Giunti-Organizzazioni Speciali.

Berninger, V. W., Nielsen, K. H., Abbott, R. D., Wijsman, E., & Raskind, W. (2008). Writing problems in developmental dyslexia: Under-recognized and under-treated. *Journal of School Psychology*, *46*(1), Article 1. https://doi.org/10.1016/j.jsp.2006.11.008

Biancardi, A., & Stoppa, E. (1997). Il Test delle Campanelle Modificato [Modified Bells Test] (TCM): Una proposta di studio per l'attenzione in età evolutiva. *Psichiatria Dell'infanzia e Dell'Adolescenza*, *64*(1), 73–84.

Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development*, *78*(2), 647–63. https://doi.org/10.1111/j.1467-8624.2007.01019.x

Blockmans, L., Golestani, N., Dalboni da Rocha, J. L., Wouters, J., Ghesquière, P., & Vandermosten, M. (2023). Role of family risk and of pre-reading auditory and neurostructural measures in predicting reading outcome. *Neurobiology of Language*, *4*(3), 474–500. https://doi.org/10.1162/nol_a_00111

Boets, B., Vandermosten, M., Cornelissen, P., Wouters, J., & Ghesquière, P. (2011). Coherent motion sensitivity and reading development in the transition from prereading to reading stage. *Child Development*, *82*(3), 854–69. https://doi.org/10.1111/j.1467-8624.2010.01527.x

Boets, B., Wouters, J., van Wieringen, A., De Smedt, B., & Ghesquiere, P. (2008). Modelling relations between sensory processing, speech perception, orthographic and phonological ability, and literacy achievement. *Brain and Language*, *106*(1), 29–40. https://doi.org/10.1016/j.bandl.2007.12.004

Brown, G. D., & Ellis, N. C. (1994). *Handbook of spelling: Theory, process, and intervention*. John Wiley & Sons Ltd.

Burgoyne, K., Malone, S., Lervag, A., & Hulme, C. (2019). Pattern understanding is a predictor of early Reading and arithmetic skills. *Early Childhood Research Quarterly*, *49*, 69–80. https://doi.org/10.1016/j.ecresq.2019.06.006

Carneiro, R., & Gordon, J. (2013). Warranting our future: Literacy and literacies. *European Journal of EDUCATION*, *48*(4), 476–97. https://doi.org/10.1111/ejed.12055

Castles, A., & Coltheart, M. (2004). Is there a causal link from phonological awareness to success in learning to read? *Cognition*, *91*(1), 77–111. https://doi.org/10.1016/S0010-0277(03)00164-1

Chen, Y.-J. I., Thompson, C. G., Xu, Z., Irey, R. C., & Georgiou, G. K. (2021). Rapid automatized naming and spelling performance in alphabetic languages: A meta-analysis. *Reading and Writing*, *34*(10), 2559–80. https://doi.org/10.1007/s11145-021-10160-7

Chyl, K., Fraga-González, G., Brem, S., & Jednoróg, K. (2021). Brain dynamics of typical Reading development—A review of longitudinal studies. *Npj Science of Learning*, *6*(1), 4. https://doi.org/10.1038/s41539-020-00081-5

Colè, P., Duncan, L. G., & Blaye, A. (2014, June). Cognitive flexibility predicts early reading skills. *Frontiers in Psychology*, *5*, 1–8. https://doi.org/10.3389/fpsyg.2014.00565

Cornoldi, C., & Colpo, G. (1998). *Prove di lettura MT per la scuola elementare—2 [Reading tests for primary school]*. Giunti Editore.

Cornoldi, C., Miato, L., Molin, A., & Poli, S. (2009). *PRCR-2 Prove di Prerequisito per la Diagno—si delle Di coltà di Lettura e Scrittura [Tests of prerequisites for the diagnosis of difficulties in reading and writing]*. Giunti O.S.

Costa, L.-J., Green, M., Sideris, J., & Hooper, S. R. (2018). First-grade cognitive predictors of writing disabilities in grades 2 through 4 elementary school students. *Journal of Learning Disabilities*, *51*(4), 351–62. https://doi.org/10.1177/0022219417721182

Cotton, S. M., Kiely, P. M., Crewther, D. P., Thomson, B., Laycock, R., & Crewther, S. G. (2005). A normative and reliability study for the Raven's Coloured Progressive Matrices for primary school aged children from Victoria, Australia. *Personality and Individual Differences*, *39*(3), 647–59. https://doi.org/10.1016/j.paid.2005.02.015

Daucourt, M. C., Schatschneider, C., Connor, C. M., Al Otaiba, S., Hart, S. A., & Hart, S. A. (2018, March). Inhibition, updating working memory, and shifting predict reading disability symptoms in a hybrid model: Project KIDS. *Frontiers in Psychology*, *9*, 1–16. https://doi.org/10.3389/fpsyg.2018.00238

DeBono, T., Hosseini, A., Cairo, C., Ghelani, K., Tannock, R., & Toplak, M. E. (2012). Written expression performance in adolescents with attention-deficit/hyperactivity disorder (ADHD). *Reading and Writing*, *25*, 1403–26. https://doi.org/10.1007/s11145-011-9325-8

Drijbooms, E., Groen, M. A., & Verhoeven, L. (2015). The contribution of executive functions to narrative writing in fourth grade children. *Reading and Writing*, *28*(7), 989–1011. https://doi.org/10.1007/s11145-015-9558-z

Ehri, L. C. (2014). Orthographic mapping in the acquisition of sight word Reading, spelling memory, and vocabulary learning. *Scientific Studies of Reading*, *18*(1), 5–21. https://doi.org/10.1080/10888438.2013.819356

Ellis, A. W. (2016). *Reading, writing and dyslexia (classic edition): A cognitive analysis*. Psychology Press.

Fanari, R., & Orsolini, M. (2014). *TPL-Test di prima lettura: Per bambini di prima e seconda classe di scuola primaria [TPL—First Reading Test: For First and Second Grade Primary School Children]*. Edizioni Erickson.

Franceschini, S., Gori, S., Ruffino, M., Pedrolli, K., & Facoetti, A. (2012). A causal link between visual spatial attention and reading acquisition. *Current Biology*, *22*(9), 814–9. https://doi.org/10.1016/j.cub.2012.03.013

Frisson, S., Koole, H., Hughes, L., Olson, A., & Wheeldon, L. (2014). Competition between orthographically and phonologically similar words during sentence Reading: Evidence from eye movements. *Journal of Memory and Language*, *73*, 148–73. https://doi.org/10.1016/j.jml.2014.03.004

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

Gathercole, S. E., & Baddeley, A. D. (1993). Phonological working memory: A critical building block for reading development and vocabulary acquisition? *European Journal of Psychology of Education*, *8*(3), Article 3. https://doi.org/10.1007/BF03174081

Georgiou, G. K., Aro, M., Liao, C.-H., & Parrila, R. (2016). Modeling the relationship between rapid automatized naming and literacy skills across languages varying in orthographic consistency. *Journal of Experimental Child Psychology*, *143*, 48–64. https://doi.org/10.1016/j.jecp.2015.10.017

Georgiou, G. K., & Das, J. P. (2016). What component of executive functions contributes to normal and impaired reading comprehension in young adults? *Research in Developmental Disabilities*, *49–50*, 118–28. https://doi.org/10.1016/j.ridd.2015.12.001

Georgiou, G. K., Torppa, M., Manolitsis, G., Lyytinen, H., & Parrila, R. (2012). Longitudinal predictors of reading and spelling across languages varying in orthographic consistency. *Reading and Writing*, *25*, 321–46. https://doi.org/10.1007/s11145-010-9271-x

Ghisi, M., Bottesi, G., Re, A. M., Cerea, S., Mammarella, I. C., Carroll, J. M., & Dunn, A. K. (2016, March). Socioemotional features and resilience in Italian university students with and without dyslexia. *Frontiers in Psychology*, *7*, 1–9. https://doi.org/10.3389/fpsyg.2016.00478

Grainger, J., Dufau, S., & Ziegler, J. C. (2016). A vision of reading. *Trends in Cognitive Sciences*, *20*(3), 171–9. https://doi.org/10.1016/j.tics.2015.12.008

Griffiths, Y. M., & Snowling, M. J. (2001). Auditory word identification and phonological skills in dyslexic and average readers. *Applied Psycholinguistics*, *22*(3), 419–39. https://doi.org/10.1017/S0142716401003071

Grigorakis, I., & Manolitsis, G. (2021). Longitudinal effects of different aspects of morphological awareness skills on early spelling development. *Reading and Writing*, *34*(4), 945–79. https://doi.org/10.1007/s11145-020-10098-2

Guerra, G., Tijms, J., Tierney, A., Vaessen, A., Dick, F., & Bonte, M. (2024). Auditory attention influences trajectories of symbol-speech sound learning in children with and without dyslexia. *Journal of Experimental Child Psychology*, *237*, 1–27. https://doi.org/10.1016/j.jecp.2023.105761

Hulme, C., Nash, H. M., Gooch, D., Lervåg, A., & Snowling, M. J. (2015). The foundations of literacy development in children at familial risk of dyslexia. *Psychological Science*, *26*(12), 1877–86. https://doi.org/10.1177/0956797615603702

Huschka, S. S., Georgiou, G. K., Brandenburg, J., Ehm, J.-H., & Hasselhorn, M. (2021). Examining the contribution of RAN components to reading fluency, reading comprehension, and spelling in German. *Reading and Writing*, *34*(9), 2317–36. https://doi.org/10.1007/s11145-021-10145-6

Johann, V., 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), 324–44. https://doi.org/10.1080/09297049.2019.1649381

Johnston, T. C., & Kirby, J. R. (2006). The contribution of naming speed to the simple view of reading. *Reading and Writing*, *19*, 339–61. https://doi.org/10.1007/s11145-005-4644-2

Kellogg, R. T., Whiteford, A. P., Turner, C. E., Cahill, M., & Mertens, A. (2013). Working memory in written composition: A progress report. *Journal of Writing Research*, *5*(2), 159–90. https://doi.org/10.17239/jowr-2013.05.02.1

Kim, Y.-S. G., & Park, S.-H. (2019). Unpacking pathways using the direct and indirect effects model of writing (DIEW) and the contributions of higher order cognitive skills to writing. *Reading and Writing*, *32*, 1319–43. https://doi.org/10.1007/s11145-018-9913-y

Kirby, J. R., Georgiou, G. K., Martinussen, R., & Parrila, R. (2010). Naming speed and reading: From prediction to instruction. *Reading Research Quarterly*, *45*(3), 341–62. https://doi.org/10.1598/RRQ.45.3.4

Konza, D. (2011). Research into practice. Understanding the reading process (vol. 1, pp. 1–8). *Department of Education and Children and Services. Government of South Australia*.

Lallier, M., Donnadieu, S., & Valdois, S. (2013, September). Investigating the role of visual and auditory search in Reading and developmental dyslexia. *Frontiers in Human Neuroscience*, *7*, 597. https://doi.org/10.3389/fnhum.2013.00597

Landerl, K., Freudenthaler, H. H., Heene, M., De Jong, P. F., Manolitsis, G., Parrila, R., & Georgiou, G. K. (2019). Phonological awareness and rapid automatized naming as longitudinal predictors of reading in five alphabetic orthographies with varying degrees of consistency. *Scientific Studies of Reading*, *23*(3), 220–34. https://doi.org/10.1080/10888438.2018.1510936

Landerl, K., Ramus, F., Moll, K., Lyytinen, H., Leppänen, P.H.T., Lohvansuu, K., O'Donovan, M., Williams, J., Bartling, J., Bruder, J., Kunze, S., Neuhoff, N., Tõth, D., Honbolygõ, F., Csépe, V., Bogliotti, C., Iannuzzi, S., Chaix, Y., & Démonet, J. F., … G. Schulte-Körne (2013). Predictors of developmental dyslexia in European orthographies with varying complexity. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *54*(6), Article 6. https://doi.org/10.1111/jcpp.12029

Livingston, E., Siegel, L., & Ribary, U. (2018). Developmental dyslexia: Emotional impact and consequences. *Australian Journal of Learning Difficulties*, *23*(2). https://doi.org/10.1080/19404158.2018.1479975

Lorusso, M. L., Vernice, M., Dieterich, M., Brizzolara, D., Mariani, E., Masi, S. D., D'Angelo, F., Lacorte, E., & Mele, A. (2014). The process and criteria for diagnosing specific learning disorders: Indications from the consensus conference promoted by the Italian National Institute of Health. *Annali Dell'Istituto Superiore Di Sanita*, *50*, 77–89.

Lyytinen, H., Shu, H., & Richardson, U. (2017). *Predictors of reading skills across languages*. In E. L. Bavin & L. R. Naigles (Eds.), *The Cambridge handbook of child language* (pp. 703–23). Cambridge University Press.

Manolitsis, G., Georgiou, G., Stephenson, K., & Parrila, R. (2009). Beginning to read across languages varying in orthographic consistency: Comparing the effects of non-cognitive and cognitive predictors. *Learning and Instruction*, *19*(6), 466–80. https://doi.org/10.1016/j.learninstruc.2008.07.003

Marotta, L., Trasciani, M., & Vicari, S. (2008). *Test CMF. Valutazione delle competenze metafonologiche. Con CD-ROM.* Edizioni Erickson.

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), 322–52. https://doi.org/10.1037/a0026744

Menghini, D., Finzi, A., Benassi, M., Bolzani, R., Facoetti, A., Giovagnoli, S., Ruffino, M., & Vicari, S. (2010). Different underlying neurocognitive deficits in developmental dyslexia: A comparative study. *Neuropsychologia*, *48*(4), 863–72. https://doi.org/10.1016/j.neuropsychologia.2009.11.003

Moll, K., Go bel, S. M., Gooch, D., Landerl, K., & Snowling, M. J. (2016). Cognitive risk factors for specific learning disorder: Processing speed, temporal processing, and working memory. *Journal of Learning Disabilities*, *49*(3), 272–81. https://doi.org/10.1177/0022219414547221

Moll, K., Ramus, F., Bartling, J., Bruder, J., Kunze, S., Neuhoff, N., Streiftau, S., Lyytinen, H., Leppänen, P.H.T., Lohvansuu, K., Tóth, D., Honbolygó, F., Csépe, V., Bogliotti, C., Iannuzzi, S., Démonet, J. F., Longeras, E., Valdois, S., & George, F., … K. Landerl (2014). Cognitive mechanisms underlying reading and spelling development in five European orthographies. *Learning and Instruction*, *29*, 65–77. https://doi.org/10.1016/j.learninstruc.2013.09.003

Morris, B. M., & Lonigan, C. J. (2022). What components of working memory are associated with children's Reading skills? *Learning and Individual Differences*, *95*, 102114. https://doi.org/10.1016/j.lindif.2022.102114

National Early Literacy Panel. (2008). *Developing early literacy: Report of the National Early Literacy Panel*.

Norton, E. S., & Wolf, M. (2012). Rapid automatized naming (RAN) and reading fluency: Implications for understanding and treatment of reading disabilities. *Annual Review of Psychology*, *63*(1), 427–52. https://doi.org/10.1146/annurev-psych-120710-100431

Pape, K., Bjørngaard, J. H., Westin, S., Holmen, T. L., & Krokstad, S. (2011). Reading and writing difficulties in adolescence and later risk of welfare dependence. A ten year follow-up, the

HUNT Study, Norway. *BMC Public Health*, *11*, https://doi.org/10.1186/1471-2458-11-718

Pasqualotto, A., Mazzoni, N., Benso, F., & Chiorri, C. (2024). Reading skill profiles in school-aged Italian-speaking children: A latent profile analysis investigation into the interplay of decoding, comprehension and attentional control. *Brain Sciences*, *14*(4), 390. https://doi.org/10.3390/brainsci14040390

Pasqualotto, A., & Venuti, P. (2020). A multifactorial model of dyslexia: Evidence from executive functions and phonological-based treatments. *Learning Disabilities Research & Practice*, *35*(3). https://doi.org/10.1111/ldrp.12228

Peng, P., Fuchs, D., Fuchs, L. S., Elleman, A. M., Kearns, D. M., Gilbert, J. K., Compton, D. L., Cho, E., & Iii, S. P. (2019). A longitudinal analysis of the trajectories and predictors of word reading and reading comprehension development among at-risk readers. *Journal of Learning Disabilities*, *52*(3). https://doi.org/10.1177/0022219418809080

Peng, P., Zhang, Z., Wang, W., Lee, K., Wang, T., Wang, C., Luo, J., & Lin, J. (2022). A meta-analytic review of cognition and reading difficulties: Individual differences, moderation, and language mediation mechanisms. *Psychological Bulletin*, *148*(3–4), 227–72. https://doi.org/10.1037/bul0000361

Peterson, R. L., & Pennington, B. F. (2012). Developmental dyslexia. *The Lancet*, *379*(9830), 1997–2007. https://doi.org/10.1016/S0140-6736(12)60198-6

Quinlan, T., Loncke, M., Leijten, M., & Van Waes, L. (2012). Coordinating the cognitive processes of writing: The role of the monitor. *Written Communication*, *29*(3), 345–68. https://doi.org/10.1177/0741088312451112

Quinn, J. M., & Wagner, R. K. (2018). Using meta-analytic structural equation modeling to study developmental change in relations between language and literacy. *Child Development*, *89*(6), 1956–69. https://doi.org/10.1111/cdev.13049

Rakhlin, N., Cardoso-Martins, C., & Grigorenko, E. L. (2014). Phonemic awareness is a more important predictor of orthographic processing than rapid serial naming: Evidence from Russian Natalia. *Scientific Studies of Reading*, *18*(6), 395–414. https://doi.org/10.1080/10888438.2014.918981

Raven, J. J. (2003). Raven progressive matrices. In R. S. McCallum (Ed.), *Handbook of nonverbal assessment* (pp. 223–37). Springer US. https://doi.org/10.1007/978-1-4615-0153-4_11

Ruffini, C., Osmani, F., Martini, C., Giera, W.-K., & Pecini, C. (2024). The relationship between executive functions and writing in children: A systematic review. *Child Neuropsychology*, *30*(1), 105–63. https://doi.org/10.1080/09297049.2023.2170998

Sartori, G., Remo, J., & Tressoldi, P. E. (1995). *Batteria per la valutazione della dislessia e della disortografia evolutiva-2 [Battery for the assessment of developmental Reading and spelling disorders]*. O.S.

Savage, R. S., & Frederickson, N. (2006). Beyond phonology: What else is needed to describe the problems of below-average readers and spellers? *Journal of Learning Disabilities*, *39*(5), 399–413. https://doi.org/10.1177/00222194060390050301

Schatschneider, C., Fletcher, J. M., Francis, D. J., Carlson, C. D., & Foorman, B. R. (2004). Kindergarten prediction of Reading skills: A longitudinal comparative analysis. *Journal of Educational Psychology*, *90*(2), 265–82. https://doi.org/10.1037/0022-0663.96.2.265

Schmitterer, A. M. A., & Schroeder, S. (2019). Effects of reading and spelling predictors before and after school entry: Evidence from a German longitudinal study. *Learning and Instruction*, *59*(June 2017), 46–53. https://doi.org/10.1016/j.learninstruc.2018.09.005

Seymour, P. H. K. (2005). Early Reading development in European orthographies. In M. J. Snowling & C. Hulme (Eds.), *The science of Reading: A handbook* (pp. 296–315). Blackwell Publishing. https://doi.org/10.1002/9780470757642.ch16

Snider, V. E. (1995). A primer on phonemic wareness: What it is, why it's important, and how to teach it. *School Psychology Review*, *24*(3), 443–55. https://doi.org/10.1080/02796015.1995.12085781

Snowling, M. J., Lervåg, A., Nash, H. M., & Hulme, C. (2019). Longitudinal relationships between speech perception, phonological skills and reading in children at high risk of dyslexia. *Developmental Science*, *22*(July 2018), 1–12. https://doi.org/10.1111/desc.12723

St Clair-Thompson, H. L., & Gathercole, S. E. (2006). Executive functions and achievements in school: Shifting, updating, inhibition, and working memory. *Quarterly Journal of Experimental Psychology*, *59*(4), 745–59. https://doi.org/10.1080/17470210500162854

Stella, G., & Savelli, E. (2011). *Dislessia oggi. Prospettive di diagnosi e intervento in italia dopo la legge 170 [Dyslexia today. Perspectives on diagnosis and intervention in Italy after law 170]*. Edizioni Erickson.

Swanson, H. L., & Berninger, V. (1995). The role of working memory in skilled and less skilled readers' comprehension. *Intelligence*, *21*(1), 83–108. https://doi.org/10.1016/0160-2896(95)90040-3

Swanson, H. L., Trainin, G., Necoechea, D. M., & Hammill, D. D. (2003). Rapid naming, phonological awareness, and reading: A meta-analysis of the correlation evidence. *Review of Educational Research*, *73*(4), 407–40. https://doi.org/10.3102/00346543073004407

Tang, J., Ma, X., Peng, P., Cha, K., Yao, Y., & Zhao, J. (2023). Visual attention span deficit in developmental dyslexia: A meta-analysis. *Research in Developmental Disabilities*, *141*, 104590. https://doi.org/10.1016/j.ridd.2023.104590

Tobia, V., & Marzocchi, G. M. (2014). Predictors of reading fluency in Italian orthography: Evidence from a cross-sectional study of primary school students students. *Child Neuropsychology*, *20*(4), 449–69. https://doi.org/10.1080/09297049.2013.814768

Torppa, M., Lyytinen, P., Erskine, J., Eklund, K., & Lyytinen, H. (2010). Language development, literacy skills, and predictive connections to reading in Finnish children with and without familial risk for dyslexia. *Journal of Learning Disabilities*, *43*(4), 308–21. https://doi.org/10.1177/0022219410369096

Torppa, M., Tolvanen, A., Poikkeus, A. M., Eklund, K., Lerkkanen, M. K., Leskinen, E., & Lyytinen, H. (2007). Reading development subtypes and their early characteristics. *Annals of Dyslexia*, *57*(1), 3–32. https://doi.org/10.1007/s11881-007-0003-0

Valdois, S. (2022). The visual-attention span deficit in developmental dyslexia: Review of evidence for a visual-attention-based deficit. *Dyslexia*, *28*(4), 397–415. https://doi.org/10.1002/dys.1724

Vanderberg, R., & Swanson, H. L. (2007). Which components of working memory are important in the writing process? *Reading and Writing*, *20*, 721–52. https://doi.org/10.1007/s11145-006-9046-6

Varvara, P., Varuzza, C., Sorrentino, A. C. P., Vicari, S., & Menghini, D. (2014, March). Executive functions in developmental dyslexia. *Frontiers in Human Neuroscience*, *8*, 120. https://doi.org/10.3389/fnhum.2014.00120

Vellutino, F. R., Fletcher, J. M., Snowling, M. J., & Scanlon, D. M. (2004). Specific reading disability (dyslexia): What have we learned in the past four decades? *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *45*(1), 2–40. https://doi.org/10.1046/j.0021-9630.2003.00305.x

Vidyasagar, T. R. (2013, November). Reading into neuronal oscillations in the visual system: Implications for developmental dyslexia. *Frontiers in Human Neuroscience*, *7*, 1–10. https://doi.org/10.3389/fnhum.2013.00811

Wolff, U. (2014). RAN As a predictor of reading skills, and vice versa: Results from a randomised reading intervention. *Annals of Dyslexia*, *64*, 151–65. https://doi.org/10.1007/s11881-014-0091-6

Ziegler, J. C., Bertrand, D., Tóth, D., Csépe, V., Reis, A., Faísca, L., Saine, N., Vaessen, A., & Blomert, L. (2010). Orthographic depth and its impact on universal predictors of reading: A cross-language investigation. *Psychological Science*, *21*(4). https://doi.org/10.1177/0956797610363406

Ziegler, J. C., & Goswami, U. (2005). Reading acquisition, developmental dyslexia, and skilled reading across languages: A psycholinguistic grain size theory. *Psychological Bulletin*, *131*(1), 3–29. https://doi.org/10.1037/0033-2909.131.1.3

Ziegler, J. C., Perry, C., & Zorzi, M. (2014). Modelling reading development through phonological decoding and self-teaching: Implications for dyslexia. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *369*(1634), 20120397. https://doi.org/10.1098/rstb.2012.0397

Ziegler, J. C., Perry, C., & Zorzi, M. (2020). Learning to read and dyslexia: From theory to intervention through personalized computational models. *Current Directions in Psychological Science*, *29*(3), 293–300. https://doi.org/10.1177/0963721420915873