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# Predictive and concurrent relations between literacy skills in Grades 1 and 3: A longitudinal study of Italian children

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ABSTRACT

A sample of 170 Italian children was assessed for reading accuracy, reading speed, text comprehension and spelling in Grades 1 and 3 in order to investigate the concurrent and longitudinal relationships among literacy skills. Main results from multivariate analyses (regression, discriminant and path analyses) indicated that reading speed was the best predictor of later literacy and that spelling was the most stable measure and influenced text comprehension and reading speed. An asymmetry was also observed in the longitudinal relationship between reading and spelling errors, with reading errors predicting later spelling errors and a non-significant result in the opposite direction.



## 1. Introduction

Literacy involves different skills such as speed and accuracy in decoding print, text comprehension and spelling dictation. A range of cognitive and language pre-literacy abilities have been found to predict the development of literacy skills (see for recent reviews Kirby, Desrochers, Roth, & Lai, 2008; Pufpaff, 2009), but less is known about the predictive power of early reading and spelling measures on later literacy acquisition. In particular, there are two issues that have been less systematically examined despite their educational relevance. First, to what extent are early reading skills, including both accurate/fluent text reading (decoding) and effective reading comprehension, predictive of subsequent literacy skills? Second, is spelling a reliable early marker of children's typical literacy development? On the one hand answers to such questions could help teachers to identify children who are at risk of scholastic underachievement. Analyzing the predictive and concurrent relationships between different literacy skills and their changes across grades could also, on the other hand, help to enrich theoretical models of reading and spelling development.

In the following sections we will address these issues by overviewing the main results for the predictive and concurrent relations between accurate/fluent reading, text comprehension and spelling skills with special focus on early grades.

### 1.1. Predictors of later literacy acquisition

Although there are strong theoretical reasons to assume that individual differences in children's early academic skills are linked to subsequent achievement, little systematic research has been conducted to test this hypothesis. A recent and very extensive study was conducted by Duncan et al. (2007) on six longitudinal data sets for a total of more than 15,000 children from the United States, Canada and Great Britain, in order to assess the power of school-entry academic, attention, and socio-emotional skills to predict later school reading and math achievement. Across all six studies, a composite measure of reading was one of the strongest predictors (along with math and attention skills) of later achievement whereas measures of socio-emotional behaviours were generally insignificant predictors of later academic performance. Patterns of association were independent of gender and socio-economic background. Unfortunately no results are reported in this study for the predictive power of spelling measures or component skills of reading ability such as accuracy, speed or comprehension.

### 1.2. Stability of reading and spelling measures

Investigating which different early literacy skills significantly contribute to later academic performance can provide important information on early markers of children's subsequent underachievement. The stability of a particular literacy skill, on the other hand, is concerned with the probability that a child with poor performance in that skill in an earlier grade will perform poorly in

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the same skill in later grades. Thus it is important to know which is the most stable literacy skill.

Longitudinal studies carried out with different aims and analyzing different literacy skills (Badian, 2001; Caravolas, Hulme, & Snowling, 2001; Georgiou, Parrila, & Papadopoulos, 2008; Phillips, Norris, Osmond, & Maynard, 2002; Seigneuric & Ehrlich, 2005) found a significant link between a literacy skill assessed in Grade 1 and the same skill retested in a later grade *(autoregressive effect)*. Although these findings are suggestive of developmental stability of reading and spelling skills from Grade 1 to later grades, we do not actually know whether some measures are more stable than others, as such results come from different tests and age populations and the effects of other variables are controlled for in many studies.

### 1.3. Reading comprehension and other reading skills

To what extent does fast and accurate word decoding in early grades affect reading comprehension both at the same grade and later?

Although a wide range of heterogeneous linguistic and cognitive mechanisms affect reading comprehension (Goff, Pratt, & Ong, 2005; Jenkins, Fuchs, van den Broek, Espin, & Deno, 2003; Klauda & Guthrie, 2008; Pazzaglia, Cornoldi, & Tressoldi, 1993; Verhoeven, Reitsma, & Siegel, 2011), it is clear that inaccurate word decoding impairs reading comprehension at an early stage of reading development (Storch & Whitehurst, 2002). The relationship between reading accuracy and reading comprehension, however, changes with development. In fact, reading accuracy accounts for a high proportion of reading comprehension variance in the lower grades, whereas factors other than word decoding contribute to reading comprehension among older children (Adlof, Catts, & Little, 2006; Gough, Hoover, & Peterson, 1996; Ouellette & Beers, 2010; Seigneuric & Ehrlich, 2005; Storch & Whitehurst, 2002). Paris, Carpenter, Paris, and Hamilton (2005) and Paris (2005) observe that this pattern of results is due to *codependency* between reading accuracy and text comprehension. Given that decoding the words is a necessary (but not sufficient) condition for understanding text, it should not be surprising that children who cannot recognize many words in a passage also cannot comprehend it. The authors claim that "… oral reading accuracy is not correlated usually or generally or simply with reading comprehension… instead it is the lack of accurate oral reading that is correlated with the lack of comprehension" (Paris et al., 2005, p. 140) thus the correlation would disappear when skilled readers are considered.

A number of researchers have also proposed a relationship between text comprehension and reading fluency, a composite measure of accuracy and speed scores (for reviews see Bashir & Hook, 2009). The best known theory concerning the role of fluency in text comprehension (LaBerge & Samuels, 1974) affirms that individuals have a limited pool of attentional resources available for any cognitive task and the more attention a reader has to focus on decoding each individual word, the less attention will be available for comprehension. Efficient fluent word recognition frees up processing resources to focus on comprehension whereas slow word recognition may place demands on remembering what is read and therefore interfere with effective comprehension. As noted earlier, factors other than decoding become important for good comprehension as decoding improves, thus the relation between fluency and text comprehension would weaken as proficiency in reading increases. This hypothesis is in agreement also with Paris et al. (2005) and Paris' (2005) *codependency* notion, described above. In fact, even though text comprehension is less dependent on reading speed than on reading accuracy (Paris, 2005), the fluency measure always includes accuracy assessment, thus the contributions of fluency and reading accuracy to text comprehension should show a similar trend. According to this view, a decline in the relationship between reading fluency and text comprehension across grades can be observed in the bivariate correlations or in the paths reported by Paris et al. (2005), Adlof et al. (2006) and Schwanenflugel et al. (2006).

As regards the longitudinal prediction of reading comprehension, Grade 1 reading accuracy seems, however, to have a significant influence on reading comprehension until Grade 3 (Muter, Hulme, Snowling, & Stevenson, 2004; Seigneuric & Ehrlich, 2005) and Grade 4 (Storch & Whitehurst, 2002). Significant correlations were also found between Grade 2 reading fluency and Grade 4 text comprehension (Adlof et al., 2006).

### 1.4. Studies on reading in transparent orthographic contexts

Transparent orthographies are those in which grapheme–phoneme correspondences are mainly one-to-one. Conversely, several graphemes may correspond to the same phoneme and several phonemes may be represented by the same grapheme in opaque orthographies. Some cross-linguistic studies have been conducted to explore whether the course of reading acquisition might differ across orthographies varying in the regularity between letters and sounds.

Seymour, Aro, and Erskine (2003) and Aro and Wimmer (2003) measured Grade 1 reading performance in several languages varying in orthographic depth. Results showed that reading accuracy decreased as orthographic depth increased, ranging from 90–98% of Finnish and Swedish children to 35–50% of English children. Aro and Wimmer (2003) claim that the complex grapheme–phoneme relations in the English orthography are confusing for beginning readers making phonological decoding very hard to acquire. Other cross-linguistic studies found lower reading levels for English-speaking children in early grades, comparing them with German- (Mann & Wimmer, 2002; Wimmer & Frith, 1997), Dutch- (Patel, Snowling, & de Jong, 2004), Greek- (Georgiou, Parrila, & Liao, 2008; Manolitsis, Georgiou, Stephenson, & Parrila, 2009) and Italian-speaking children (Romani, Zoccolotti, & Marinelli, 2011). Monolingual studies also confirmed Seymour et al. (2003) and Aro and Wimmer (2003) results showing that in transparent orthographic contexts reading accuracy is often close to or at ceiling before the end of the first year of formal instruction (e.g. Landerl & Wimmer, 2008; Orsolini, Fanari, Tosi, De Nigris, & Carrieri, 2006).

Other studies on transparent orthographies demonstrated that word-reading speed, not accuracy, is the reading measure differentiating between good and poor readers (e.g. Serrano & Defior, 2008; Zoccolotti et al., 1999). Moreover, Landerl and Wimmer (2008) observed high stability for word-reading speed development in a group of German children followed from Grade 1 to Grade 8.

The importance of reading speed as a marker of effective, typical reading development seems to have consequences for reading comprehension as well. Whereas several studies found significant associations between reading comprehension and reading accuracy in the opaque orthographic context (see Section 1.3), reading comprehension is more often or more strongly associated with reading speed, or reading fluency, in the transparent orthographic context (De Jong & van der Leij, 2002; Leppänen, Aunola, Niemi, & Nurmi, 2008; Müller & Brady, 2001; Verhoeven & van Leeuwe, 2008). However, some findings suggest that the contribution of reading fluency (or reading speed) to text comprehension decreases across grades even in transparent orthographies (e.g. Müller & Brady, 2001; Verhoeven & van Leeuwe, 2008). Given the importance of reading speed as marker of effective reading development in these contexts, more research is needed on the relationship between reading speed and text comprehension.

### 1.5. Relations between spelling and reading skills

Theoretical models of reading/spelling development (e.g. Frith, 1985) often state that reading and spelling are initially quite separate abilities. In the Frith's (1985) model children begin to develop literacy skills by first reading words logographically using partial visual cues. Children in an initial stage of writing, on the other hand, attempt to spell words the way they sound, on a one-sound-to-one-letter basis, and only later transfer their emerging alphabetic knowledge of letter-sound correspondences to reading. Therefore during the first stage children tend to read visually (holistically) and, at the same time, to spell phonologically (discrepancy hypothesis).

The Frith's discrepancy hypothesis was examined and rejected by Fletcher-Flinn, Shankweiler, and Frost (2004). They investigated reading and spelling of Grade 1 and Grade 2 English-speaking children using controlled word and non word materials with a variety of orthographic patterns. The results showed that children's accuracy of reading and spelling the same words and non words was closely correlated even at the early stages of literacy acquisition (after about 4 months of schooling).

Two works considering large samples of English-speaking children from Grades 1 to 6 (Berninger, Abbott, Abbott, Graham, & Richards, 2002) and 1 to 4 (Mehta, Foorman, Branum-Martin, & Taylor, 2005) evidenced significant and strong concurrent relations between reading accuracy and spelling accuracy in all grades, suggesting that the two skills are intertwined along the whole literacy acquisition process. Both reading and spelling skills are based on the knowledge of conversion rules (grapheme–phoneme for reading and phoneme–grapheme for spelling[1]) and depend on extraction of both word-specific and language-specific orthographic regularities. Although it would seem quite obvious that reading and spelling contribute to one another in a reciprocal relationship (Berninger et al., 2002) the underlying nature of this link has not yet been clarified. According to the *self-teaching hypothesis* (Share, 1995) in its more recent version (Shahar-Yames & Share, 2008) the translating processes from both grapheme to phoneme in reading and phoneme to grapheme in spelling fulfil a self-teaching function, enabling the reader to independently acquire orthographic knowledge, that is orthographic conventions and word-specific orthographic representations in long term memory. Orthographic representations are crucial not only for spelling development but also for skilled word recognition given that they allow the immediate activation of the phonological form of the word in memory (Shahar-Yames & Share, 2008). The concurrent relation between reading and spelling accuracy might thus be bidirectional along the whole learning process.

As far as the longitudinal relationship between spelling and reading accuracy is concerned, controversial results are obtained. Significant and symmetrical relationships were observed between the two skills measured at the beginning and the end of Grade 1 (Foorman, Francis, Novy, & Liberman, 1991) and in longitudinal relationships evaluated across adjacent grades from 1 to 7 (Abbott, Berninger, & Fayol, 2010). Other studies found either a stronger contribution of early spelling to later reading than early reading to later spelling (e.g. Cataldo & Ellis, 1988), or the opposite pattern of results (e.g. Caravolas et al., 2001).

Only a few studies have investigated the relationship between spelling and text comprehension. Both Berninger et al. (2002) and Mehta et al. (2005) found strong concurrent relations between the two skills in all grades. The authors did not discuss that finding as it was beyond the scope of their study, but it is noteworthy that whereas the relationship between reading comprehension and reading accuracy seems to be restricted to earlier grades (see Section 1.3), spelling appears to be connected to reading comprehension even in later grades. The new version of the *self-teaching hypothesis* (Shahar-Yames & Share, 2008), supported by the authors' within-subjects study of Grade 3 Hebrew readers, predicts not only that spelling a novel word would lead to significant orthographic learning but also that spelling would actually be superior to reading in favouring the acquisition of word-specific orthographic representations owing to the unique processing demands involved in reproducing from memory the complete array of letters. Orthographic knowledge, on the other hand, is considered crucial for text comprehension (Apel, 2009; Katzir et al., 2006) as it facilitates automatic word recognition. Thus the contribution of spelling to skilled word recognition and therefore to effective text comprehension is likely to be stronger (and maybe more stable) than the contribution of reading accuracy.

### 1.6. Relations between spelling and reading in transparent orthographies

For many transparent orthographies, such as German (Wimmer & Mayringer, 2002), Spanish (Defior, Jimenez Fernandez, & Serrano, 2009), Dutch (Bekebrede, van der Leij, & Share, 2009) and Italian too (Angelelli, Notarnicola, Judica, Zoccolotti, & Luzzatti, 2010), regularity refers more to grapheme–phoneme (forward regularity) than to phoneme–grapheme (backward regularity) conversion. In fact these orthographies present a certain degree of ambiguity in the sound-to-print direction as some phonological strings have more than one possible orthographic solution, though only one is correct. In these cases unpredictable spelling occurs.

Caravolas (2004) theorizes that if sound-to-print consistency has the same effect on spelling that print-to-sound consistency has on reading, then children learning an orthography with high sound-to-print consistency should learn to spell more quickly than those learning a sound-to-print inconsistent orthography. Unfortunately much less cross-linguistic work has focused on spelling development than on reading development. In their cross-linguistic study Caravolas and Bruck (1993) showed that spelling develops more slowly in Grade 1 English children than in children learning to read Czech orthography, which is highly consistent in the sound-to-print direction (Caravolas, 2004). Analogous results emerged in a cross-linguistic study on spelling development in older English and Italian children (Romani et al., 2011). The authors found that a group of English children made a number of spelling errors that was more than twice the number of errors made by the Italian children, even though the English children started school one year younger and Italian language is not fully transparent in the sound-to-print direction.

Wimmer and Landerl (1997) and Caravolas (2004) argued that in transparent orthographies with more consistent grapheme–phoneme than phoneme–grapheme conversion rules, early reading provides an indirect benefit to early spelling as well, promoting the acquisition of phonological spelling (sequential sound-letter encoding). This process, in turn, enables learners to create phonological scaffolds onto which more complex conventional graphemes can be mapped, improving the acquisition of conventional spelling. According to Wimmer and Landerl's (1997) and Caravolas' (2004) hypothesis we can make two predictions concerning the longitudinal relationships between reading and spelling accuracy: a) the reciprocal longitudinal contributions of reading and spelling accuracy should be symmetrical in transparent orthographies characterized by both forward and backward

[1] In the present study we use the terms *phoneme* and *grapheme* for reasons of brevity, also including sub-lexical unities (i.e. syllables) larger than one phoneme or one grapheme.

regularity; b) early reading should be a strong predictor of later spelling whereas early spelling should be a weak predictor of later reading in transparent orthographies with more consistent grapheme–phoneme than phoneme–grapheme conversion rules.

Results in agreement with our first prediction emerge from a study on Turkish orthography (Babayigit & Stainthorp, 2011) - which is characterized by both forward and backward regularity (Babayigit & Stainthorp, 2007; Caravolas, 2004) - showing that the bivariate correlation between early reading and later spelling (assessed one year after) was comparable to the correlation between early spelling and later reading.

A partial support to our second prediction is provided by the results of two studies on Dutch orthography which is more consistent in the sound-to-print than in the print-to-sound direction. Keuning and Verhoeven (2008) examined a pseudo-longitudinal dataset (combining longitudinal and cross-sectional data) of more than 1300 children from Grades 2 to 6, and found that good readers achieved a high level of spelling ability within a relatively short period of time whereas poor readers required more time and often did not even come close to the spelling level of good readers. Unfortunately the contribution of early spelling to later reading was not assessed in this study. In the Van Weerdenburg, Verhoeven, Bosman, and van Balkom's (2011) longitudinal study, the contribution of Grade 1 reading accuracy to Grade 2 spelling accuracy was 10% higher than the contribution of Grade 1 spelling accuracy to Grade 2 reading accuracy. However, as children in this study had been diagnosed with specific language impairment, more research on children with typical development is needed to better understand the longitudinal relationship between reading and spelling in transparent orthographic contexts with backward–forward asymmetry.

### 1.7. The context of the present study

In Italy, formal instruction of reading and writing begins in primary school when children are six years old. Reading and spelling are mainly taught through phonics by training sound-letter and letter-sound correspondences. Studies of Italian children show that in the earliest stages of learning, reading aloud mainly depends on phonological recoding but the ability to recognize words accessing their orthographic representations in memory (lexical reading) improves across the first two grades (Orsolini et al., 2006) and especially increases in Grade 3, allowing more rapid and fluent word recognition (Zoccolotti, De Luca, Di Filippo, Judica, & Martelli, 2009).

As regards print-to-sound consistency, Italian is one of the most transparent among alphabetic orthographies. For instance, considering the *entropy index* calculated by Borgwaldt, Hellwig, and de Groot (2005), Hungarian is the most predictable among the seven orthographies examined by the authors (entropy = 0.15), followed by Italian (0.20), whereas English has the highest value (0.55). For what concerns sound-spelling consistency, a very basic indicator is the ratio of phonemes to letters (Caravolas, 2004). In Italian it is 27/21 (Bonvino, 2000), that is 1.3:1. In Czech it is 1:1, in French 1.5:1 and in English is 1.7:1 (Caravolas, 2004).

As far as the asymmetry between forward and backward regularity is concerned, no quantitative data have been calculated for Italian, but there is agreement (e.g. Angelelli et al. 2010; Cossu, 1999) that Italian orthography is more regular in the print-to-sound than in the sound-to-print direction. In fact some phonemic and prosodic patterns are represented by inconsistent or word-specific orthographic characteristics. For example, the phonemic group [kw] is orthographically represented by the sequences CU (*cuoco*), QU (*quaderno*) and CQU (*acqua*) in words such as [kwoko], *cook*, [kwaderno], *handbook*, or [akkwa], *water*, respectively. Prosodic markers in Italian are also relatively inconsistent in their relationship with orthography. The word stress, for instance, is orthographically marked only when it shows the atypical pattern of falling on the last syllable in polysyllabic words, as in *papà (daddy)*, or *lui telefonò (he called)*. Another example of inconsistent relationship between prosody and orthography is the lengthening of consonants that occurs in syllable codas that is always orthographically marked as a double letter (e.g. [kan.ne], *reeds*, written as *canne*) except for some types of consonants (such as the fricative [ʃ] in [koʃ.ʃa, *thigh*, written as *coscia*). Many words in Italian have stress on the last syllable or contain doubled consonants and there are also a number of minimal pairs of words sharing the same phonemic structure but differing in orthography only for one of the two markers, such as *papa (pope)* and *papà (dad)* or *cane (dog)* and *canne (reeds)*. The application of the phoneme–grapheme conversion rules alone is thus not sufficient for assembling the right orthography of words like *papà* or *canne* and the correct writing of this kind of words is enhanced by word-specific orthographic representations. Angelelli, Judica, Spinelli, Zoccolotti, and Luzzatti (2004) evidenced that poor processing in the lexical procedure produces spelling errors when a lexical representation is necessary to solve orthographic ambiguities.

### 1.8. Aims and hypotheses

In this longitudinal study we assessed a sample of 170 children for reading accuracy, reading speed, text comprehension and spelling first in Grade 1 and then in Grade 3. We investigated the relationships between our reading and spelling measures with three different aims. First, we considered a composite literacy acquisition score in Grade 3 and asked which skills assessed in Grade 1 were the strongest predictors of such scores. Second, we evaluated the extent to which each skill assessed in Grade 1 was longitudinally related to the same skill assessed in Grade 3. Third, we analyzed the concurrent effects of spelling and decoding on reading comprehension first in Grade 1 and then in Grade 3, in order to explore if these effects change across grades.

To the best of our knowledge this is the first work on early grades in which the relationships between reading accuracy, reading speed, reading comprehension and spelling are assessed both concurrently and longitudinally in a transparent orthographic context, thus our aims were mainly exploratory. On the basis of the literature considered in the previous sections, however, some hypotheses can be advanced.

As regards the literacy predictors and the longitudinal relationships between the measures, we hypothesized both Grade 1 reading speed (but not reading accuracy) to be a significant predictor of individual differences in Grade 3 literacy (Hypothesis 1a) and reading speed to be more stable than reading accuracy (Hypothesis 1b), given the importance of reading speed as a marker of effective reading development in transparent orthographic context (see Section 1.4).

If the early acquisition of grapheme–phoneme conversion rules produces an indirect advantage in the acquisition of phoneme–grapheme conversion rules, because of the asymmetry in regularity between reading and spelling in Italian (see Section 1.7), we also expected an asymmetry in the longitudinal relationship between reading and spelling errors, with reading errors significantly predicting spelling errors and spelling errors as non-significant predictors of reading errors (Hypothesis 2a). In this study three different types of spelling error (Re, Pedron, & Cornoldi, 2007) were analyzed: Phonologically Incorrect, owing to the incorrect association between phonemes and graphemes, Phonologically Correct but orthographically incorrect (as for [kwoko] written *quoco*), and errors on Stress Mark and Doubled Consonants. We expected the asymmetry between reading and spelling to be shown most clearly by the longitudinal relationship between reading errors and phonologically incorrect

spelling errors (Hypothesis 2b), given that this kind of error is an indicator of the efficiency of application of phoneme–grapheme conversion rules.

As regards the concurrent relations between literacy skills, we made the following predictions. According to results observed in English-speaking children (Storch & Whitehurst, 2002) and evidences from transparent orthographies (Müller & Brady, 2001; Verhoeven & van Leeuwe, 2008) we expected decoding (that is, accuracy and speed in reading) to influence reading comprehension in Grade 1 more than in Grade 3 (Hypothesis 3a). Conversely, spelling should be significantly related to reading comprehension in both grades (Hypothesis 3b), given the results obtained in the opaque orthographic context (Berninger et al., 2002; Mehta et al., 2005) and the lack of indications in research on transparent orthographies that different results should be expected. Finally, we expected the relation between reading speed and reading comprehension to be stronger than the relation between reading accuracy and reading comprehension (Hypothesis 3c), in agreement with results obtained in transparent orthographic contexts (e.g. Müller & Brady, 2001).

## 2. Method

### 2.1. Participants and design

One hundred and seventy Italian children (mean age = 106.0 months; SD = 3.7; 78 boys) participated in the study, all being of lower-middle socio-economic status and attending the Grade 3 class of primary schools in Rome. At the end of Grade 1 they had participated in a previous work (Scalisi, Desimoni, & Pelagaggi, 2009) in which 453 children from ten schools had been examined with reading and spelling standardized tests. All the 453 children were native speakers of Italian and none of them had been diagnosed with deficits of neurological function or of sensory-motor ability, or had measures of general intellective functioning below the 10° percentile of the Italian norms (Belacchi, Scalisi, Cannoni, & Cornoldi, 2008) of the Coloured Progressive Matrices (Raven, 1947). Children had not experienced formal instruction on reading and spelling in kindergarten.

Two years after the first assessment we contacted the head teachers of the schools and invited them to allow children to participate in a second assessment but five of them declined, as the schools were involved in other research projects. The total number of children examined in Grade 1 in the five schools who agreed to participate in the Grade 3 assessment was 176. No children were admitted to the longitudinal sample who, after the first assessment, had been found to have poor attendance records, or who had been diagnosed with deficits of neurological function or of sensory-motor ability, or had been in special education programmes. On the basis of these criteria six children were discarded. Reading and spelling standardized tests were administered to the 170 children of the final longitudinal sample at the end of Grade 3.

### 2.2. Materials

#### 2.2.1. Reading tests

Reading speed, accuracy and comprehension were evaluated by means of the MT standardized battery (Cornoldi & Colpo, 1998) consisting of different materials for children in Grades 1–8. To assess speed and accuracy the child is asked to read aloud a short story as fast and accurately as possible. The story for the end of Grade 1 contains 75 words, and the story for the end of Grade 3 contains 141 words. A stopwatch was used to measure the amount of time it takes the child to read the story. The mean number of syllables read per minute (i.e. the number of syllables of each passage divided by the number of minutes taken to read the passage) was calculated to obtain the reading speed score. We used such reading speed measure because the values for skewness and kurtosis were low (0.67 and 0.37). The reciprocal score (mean number of seconds per syllable), often adopted in the MT battery usage, produced much higher skewness and kurtosis values (3.39 and 17.62). The reading error score calculated took into account the number of mistaken, omitted or added syllables along with the number of long hesitations before or while reading words and the number of errors on stress assignment.

To assess text comprehension the child is asked to read silently a narrative text and then to answer to 10 multiple-choice questions. The child is able to see the text for the entire duration of the task. The score is the number of correct answers. The manual reports parallel-form reliability coefficients that range from 0.75 to 0.87 for reading accuracy, from 0.94 to 0.96 for reading speed and from 0.57 to 0.70 for text comprehension.

#### 2.2.2. Spelling test

Children were administered the dictation test from the Batteria per la valutazione della scrittura e della competenza ortografica nella scuola dell'obbligo (BVSCO, Battery for the assessment of writing skills of children from 7 to 13 years old, Tressoldi & Cornoldi, 1991). The story for Grade 1 contains 62 words, and the story for Grade 3 contains 144 words. The test score is the total number of errors.

Following the BVSCO manual, we considered three different types of errors: Phonologically Incorrect, Phonologically Correct and errors on Stress Mark & Doubled Consonants. A Phonologically Incorrect error produces a string of letters that sounds different from the correct word and is produced by an incorrect association between phonemes and graphemes; a Phonologically Correct error occurs when the string of letters has the same sound as the correct word, such as *squola* instead of *scuola* (school), and can be produced also by illegal fusions or separations such as *laria* instead of *l'aria* (the air), indicating a good knowledge of phoneme–grapheme conversion rules but incomplete orthographic learning; errors on Stress Mark & Doubled Consonants are indicative of specific problems with the application of the rules governing word stress and double consonants and occur when the sequence of written letters corresponds to the correct one but the stress mark is lacking (e.g. *liberta* instead of *libertà*, freedom) or doubling consonants are substituted by a single one (e.g. *muca* instead of *mucca*, cow).

The test manual reports test–retest correlations of 0.78 for Phonologically Incorrect errors, 0.59 for Phonologically Correct errors and 0.48 for Stress Mark & Doubled Consonants errors. The correlations between total number of errors in the dictation test and in sentence dictation test of the same battery range from 0.66 to 0.71.

### 2.3. Procedure

Grades 1 and 3 reading and spelling tasks were administered by trained research assistants during the last three months of the school year. Reading speed and accuracy tests were administered individually in a quiet room at school, in a session lasting approximately 10 min; spelling and text comprehension tests (in that order) were administered as a group to the entire class, in a single session lasting about 1 h with a 10 min break between one task and the next.

### 2.4. Statistical analyses

The distributions of the composite scores used to estimate children's literacy violated the assumption of normality in both grades. As the literacy scores were obtained standardizing raw data

first and after calculating the mean of *z* scores for each child, we preferred not to perform further data transformations and utilized statistics with low impact of violating the assumption of normality. Therefore, descriptive statistics were used to examine the relationship between Grade 1 and Grade 3 literacy. For the same reason the longitudinal relationship between Grade 1 measures and Grade 3 literacy was assessed by means of a discriminant analysis in which Grade 3 literacy was treated as an ordinal variable and used to select groups.

Longitudinal relationships between all the single measures considered in this work were evaluated by means of a model of multivariate multiple regression. With respect to univariate multiple regressions, this method allows investigation of all outcome variables simultaneously, thus taking into account correlations between outcomes.

In order to assess the contribution of decoding to text comprehension beyond the effect of spelling (and vice versa) two different models of hierarchical multiple regression were performed to analyze the concurrent relationships between text comprehension and the other measures in each grade.

Lastly, path analysis was used to study the indirect effects of Grade 1 reading and spelling to Grade 3 text comprehension, via Grade 3 decoding and spelling.

## 3. Results and discussion

### 3.1. Attrition

Grade 1 literacy measures (reading accuracy, reading speed, text comprehension and spelling) and numbers of different type of spelling errors of the 170 children who participated in the longitudinal study were compared by means of *t* tests with the same measures assessed on the 277 children who did not participate in the longitudinal study. The six children discarded from the longitudinal study were not considered in the comparisons. All the results of the *t* test comparisons were non-significant (*t* test values ranged between −1.3 and 1.6).

### 3.2. Preliminary data analyses and descriptive statistics

The descriptive statistics for Grade 1 and 3 reading and spelling measures (raw data) are presented in Table 1.

Considering the three different types of spelling errors, the most frequent categories were Phonologically Incorrect in Grade 1 (45.03%) and Stress Mark & Doubled Consonants in Grade 3 (46.82%). Phonologically Correct errors were the least frequent in both Grade 1 and Grade 3 (18.99% and 11.84% respectively). Since the mean and maximum number of Phonologically Correct spelling errors were very low in both grades (see Table 1) this variable was not considered in the following analyses in order to avoid unreliable results. The bivariate correlations between Phonologically Correct spelling errors and the other measures are shown, however, in the Appendix.

First of all outliers and distributional properties of the variables were examined. As literacy measures are usually skewed (Paris, 2005) outliers were not evaluated on the basis of means and standard deviations. An initial examination of the distributional properties of the variables was performed through visual inspection of histograms and *extreme* values were individuated, that is those out of the *codas* of the distributions (Grade 1: one lowest value for text comprehension, three highest values for reading errors and two highest values for Phonologically Incorrect spelling errors; Grade 3: one highest value for the total number of spelling errors). Each of these values was replaced by a value equal to the next highest (or lowest) non-extreme-score plus (or minus) one unit of measurement. This procedure is suitable when the distribution of a variable is skewed in the population, therefore extreme scores are representative of population and their exclusion is not appropriate (Tabachnick & Fidell, 2001).

Skewness and kurtosis were then calculated on each measure. Both Grade 1 and 3 error scores in reading and spelling still showed positive values of skewness and kurtosis. In order to avoid dramatic reduction in variance, no other outlier values were modified, and data transformation was adopted. All the error measures, including Phonologically Incorrect and Stress Mark & Doubled Consonants spelling errors, were submitted to a square-root transformation. This procedure was not sufficient to substantially improve the distributions for Grade 3 reading errors, and a log transformation was adopted for this variable. After transformations, almost all the variables included in the design showed values between −1 and +1 for skewness and kurtosis and no value was $>|1.5|$. Transformed values of reading and spelling error measures were used in further inferential statistics.

The correlation matrix of the measures is reported in the Appendix. Age at Grade 1 was significantly correlated only with text comprehension in the same grade ($r = 0.16$; $p < 0.05$), and had very low correlations with Grade 3 measures, so it was not considered in the longitudinal analyses.

### 3.3. Prediction of Grade 3 literacy

The Appendix shows that the correlations between literacy skills were all significant ($p < 0.001$) in both grades, enabling us to calculate a *global* measure of achievement in reading and spelling that we called *literacy*.

A preliminary descriptive analysis of the relationship between Grade 1 and Grade 3 literacy levels is presented in Fig. 1. Untransformed scores were first standardized and then a literacy score was calculated separately for Grades 1 and 3 by averaging the *z* scores of text comprehension, reading errors, reading speed and spelling errors

**Table 1**
Descriptive statistics for age and reading and spelling measures in Grades 1 and 3. Frequencies for minimum and maximum values are also reported.

| Measures | Grade 1 | | | | | | Grade 3 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *M* | SD | Min | Freq. | Max | Freq. | *M* | SD | Min | Freq. | Max | Freq. |
| Age in months | 81.47 | 3.80 | 75.00 | 10 | 88.00 | 5 | 106.01 | 3.75 | 98.00 | 1 | 113.00 | 1 |
| Text comprehension (c.a.) | 6.90 | 2.30 | 0.00 | 1 | 10.00 | 22 | 7.74 | 1.80 | 2.00 | 2 | 10.00 | 31 |
| Reading errors | 7.48 | 8.96 | 0.00 | 5 | 59.39 | 1 | 3.96 | 7.92 | 0.00 | 15 | 85.00 | 1 |
| Reading speed (syll/min) | 66.79 | 33.66 | 7.00 | 2 | 187.50 | 1 | 178.76 | 60.22 | 56.25 | 1 | 333.33 | 2 |
| Spelling errors (total) | 13.84 | 11.81 | 0.00 | 2 | 62.00 | 1 | 12.13 | 9.11 | 1.00 | 3 | 46.13 | 1 |
| PC spelling errors | 2.30 | 1.51 | 0.00 | 12 | 8.03 | 1 | 1.44 | 1.41 | 0.00 | 46 | 7.41 | 1 |
| PI spelling errors | 6.23 | 8.85 | 0.00 | 17 | 52.00 | 1 | 5.02 | 4.60 | 0.00 | 15 | 26.00 | 1 |
| SM & DC spelling errors | 5.31 | 4.13 | 0.00 | 17 | 15.00 | 1 | 5.68 | 5.13 | 0.00 | 9 | 23.63 | 1 |

c.a. = Number of correct answers; syll/min = mean number of syllables read per minute; PC = phonologically correct; PI = phonologically incorrect; SM & DC = errors on stress mark and doubled consonants.

(total number); *z* scores were reflected for reading and spelling errors. Note that by using the mean of different test scores the risk of regression to the mean in examining extreme performances is greatly diminished (Aarnoutse, van Leeuwe, Voeten, & Oud, 2001).

About 76% of the children with above-average literacy scores in Grade 1 had above-average literacy scores in Grade 3, and 66% of the children with below-average literacy scores in Grade 1 had below-average literacy scores in Grade 3. These percentages indicate a relatively good stability of literacy across grades. Nevertheless the scatterplot in Fig. 1 evidences that children with above-average literacy scores in Grade 1 presented less variability in Grade 3 compared with children whose literacy scores were below-average in Grade 1. Twenty-four children with above-average scores in Grade 1 had below-average scores in Grade 3 but none of these scores was lower than $z = -1$. Turning to children with below-average literacy scores in Grade 1, Fig. 1 shows that only three of them presented a substantial decrease in literacy level (from *z* score $> -1$ in Grade 1 to *z* score $< -1$ or $< -2$ in Grade 3). As regards the 18 children with Grade 1 *z* score $< -1$, seven of them (39%) improved by more than 1 *z* point, with two reaching above-average levels.

This pattern of results evidences, in a transparent orthographic context, that children with good early literacy skills tend to maintain good (or close to mean) levels of literacy until Grade 3. Even though the performance of the majority of the children with the poorest literacy skills remained below-average in Grade 3, about 40% of these children improved their literacy levels, thus the gap with the sample mean was reduced.

Grade 3 literacy scores were translated into percentile scores. Children with scores above the seventy-fifth percentile were classified in the High Literacy group and children with scores below the twenty-fifth percentile were classified in the Low Literacy group. Each group was composed of 39 children, 17 males in the High Literacy group and 22 in the Low Literacy one. Mean ages were 105.62 and 105.51 months respectively. The Low Literacy group had lower reading and spelling scores than the High Literacy one both in Grade 1 and in Grade 3 and the differences between groups in terms of *z* scores ranged between one and two points.

A discriminant analysis was performed with Grade 3 group membership (High Literacy and Low Literacy groups) as dependent variable and Grade 1 text comprehension, spelling error (total number), reading error and reading speed scores as independent variables. Transformed data were used for error scores (see Section 3.2).

The results of the discriminant analysis are shown in Table 2. Partial Lambda refers to the unique contribution of a predictor, that is, the variance between groups that was not already accounted for by the other predictors.

Grade 1 measures explained 56.03% of literacy differences in Grade 3 ($p < 0.001$); the percentage of correct classification was 87.18 for each group. Reading speed significantly contributed to the discrimination between groups (Partial Lambda = 0.90; $p < 0.01$) but reading errors did not (Partial Lambda = 1.00; $p > 0.05$). The analysis also evidenced the predictive power of spelling skill to later literacy (Partial Lambda = 0.92; $p < 0.05$), adding a new piece of information to previous results on the prediction of later academic performance, described in Section 1.1 (Duncan et al., 2007).

### 3.4. Longitudinal relationships between reading and spelling measures

A multivariate multiple regression analysis was performed considering Grade 3 text comprehension, reading errors, reading speed and spelling errors as outcomes and the same measures in Grade 1 as predictors.

Parameters specification and estimation were conducted with LISREL 8.3 (Joreskög & Sorböm, 1999). Model tests were based upon covariance matrices and used maximum likelihood estimation. In the model all the paths from Grade 1 to Grade 3 measures were estimated, including the autoregressive and the cross-lagged paths between reading and spelling measures. Grade 1 variables were allowed to correlate freely, without causal ordering, and the relationships between the outcomes were modelled as correlate residuals. As the model of the covariance-structure for multivariate multiple regression is just-identified, we did not consider model global fit indices. The results are presented in Table 3.

The proportion of variance ($R^2$) of each outcome accounted for by all the predictors was 0.26 for text comprehension, 0.21 for

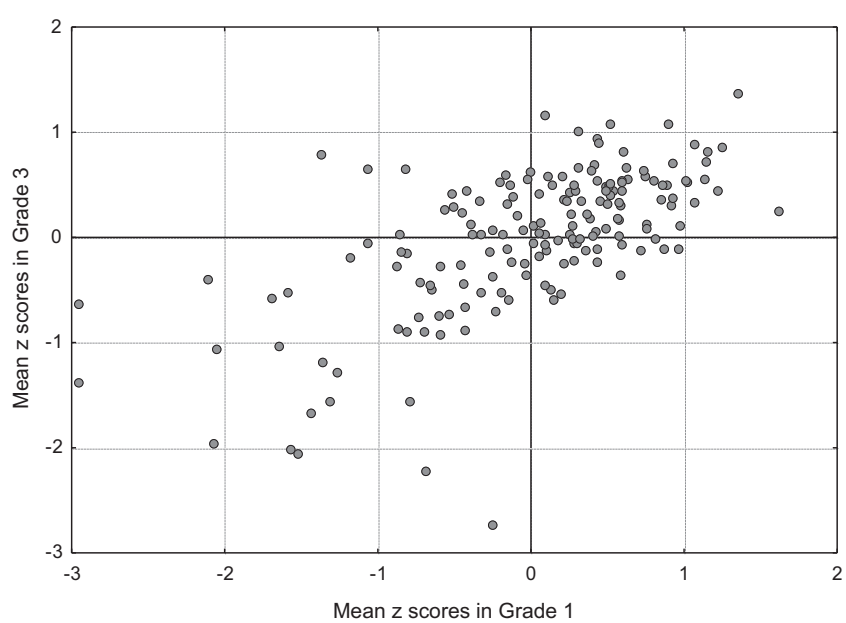


**Fig. 1.** Scatterplot for mean *z* scores in Grades 1 and 3, calculated for text comprehension, reading errors, reading speed and spelling error scores (*z* scores were reflected for reading and spelling errors).

**Table 2**
Discriminant analysis assessing Grade 1 reading and spelling measures as predictors of Grade 3 group membership (high and low literacy).

| Measures in Grade 1 | Partial $\lambda$ |
|---|---|
| Text comprehension | 0.97 |
| Reading errors | 1.00 |
| Reading speed | 0.90** |
| Spelling errors | 0.92* |
| % Total variance accounted for | 56.03*** |
| % Correct classifications HL group ($N = 39$) | 87.18 |
| % Correct classifications LL group ($N = 39$) | 87.18 |

HL = high literacy; LL = low literacy.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

reading accuracy, 0.22 for reading speed, and 0.50 for spelling; each $R^2$ value was significant with $p < 0.001$.

As regards the developmental stability of the skills across grades, each measure in Grade 3 was significantly predicted by the same measure in Grade 1 (see Table 3) with the exception of reading errors that were significantly predicted only by early reading speed ($\beta = -0.30$; $p < 0.01$). Thus reading speed was more stable than reading accuracy.

In order to assess which measure was the most stable, we calculated the percentage of unique variance (based on semipartial $R^2$) explained by each predictor. The autoregressive effect, beyond the contributions of the other predictors, was 2.85% for text comprehension, 4.21% for reading speed and 11.38% for spelling, indicating that spelling was the most stable measure. This finding is not dependent on the particular set of variables included as control, in fact it is confirmed by the values of bivariate correlations (see Appendix) between each variable in Grade 1 and the same variable in Grade 3, that is 0.39 for text comprehension, 0.43 for reading speed and 0.67 for spelling.

Examining the cross-lagged influences between measures we found that Grade 1 text comprehension did not predict any of the later measures but Grade 3 text comprehension was significantly predicted by Grade 1 reading errors ($\beta = -0.23$; $p < 0.05$). Grade 1 reading errors also predicted later spelling errors ($\beta = 0.30$; $p < 0.001$) but Grade 1 spelling errors did not predict Grade 3 reading errors. Earlier spelling errors predicted later reading speed ($\beta = -0.23$; $p < 0.05$).

We observed an asymmetry in the relationship between reading and spelling accuracy: early accurate reading facilitated the acquisition of later spelling, but previous ability in applying spelling rules did not predict later reading accuracy. One could argue that Grade 3 reading accuracy was not predicted by early spelling given the low number of reading errors in Grade 3, but since reading accuracy was significantly predicted by Grade 1 reading speed, the lack of significance in the relation between Grade 1 spelling errors and Grade 3 reading errors was not owed to the distributional properties of Grade 3 reading errors.

Given this pattern of results, we wondered if the two different types of spelling errors (Phonologically Incorrect and Stress Mark & Doubled Consonants) would differ as regards stability or would have different longitudinal relationships with reading skills, so we performed a new multivariate multiple regression analysis in which the same measures were considered but the total number of spelling errors was replaced with the numbers of spelling errors in the Phonologically Incorrect and Stress Mark & Doubled Consonants categories. Results are presented in Table 4.

The proportion of variance ($R^2$) of each outcome accounted for by all the predictors was 0.25 for text comprehension, 0.21 for reading accuracy, 0.23 for reading speed, 0.34 for Phonologically Incorrect spelling errors and 0.35 for errors on Stress Mark & Doubled Consonants; each $R^2$ value was significant with $p < 0.001$.

Both the autoregressive effects of Phonologically Incorrect and Stress Mark & Doubled Consonants spelling errors were significant ($\beta = 0.23$; $p < 0.05$ and $\beta = 0.24$; $p < 0.01$ respectively). Grade 1 Phonologically Incorrect errors also significantly predicted Grade 3 Stress Mark & Doubled Consonants errors ($\beta = 0.32$; $p < 0.001$).

The contribution of Grade 1 reading errors to Grade 3 spelling errors was significant for the Phonologically Incorrect errors ($\beta = 0.37$; $p < 0.001$) but only approached significance for the Stress Mark & Doubled Consonants errors ($\beta = 0.18$; $p = 0.054$). Conversely, neither of the two kinds of spelling error in Grade 1 significantly predicted reading errors in Grade 3. This pattern of results suggests that the asymmetry in the longitudinal relationship between reading accuracy and spelling that was shown by the previous analysis (Table 3) is mainly concerned with Phonologically Incorrect spelling errors, that is, errors generated by a weak learning of grapheme–phoneme conversion rules. This result is in agreement with Wimmer and Landerl (1997) and Caravolas (2004) in that early correct decoding can favour later spelling development in transparent orthographic contexts where an asymmetry is present between backward and forward regularity.

The two different types of spelling errors gave different results regarding the relationship with reading speed. As shown in Table 4, only Grade 1 Phonologically Incorrect spelling errors significantly predicted later reading speed ($\beta = -0.24$; $p < 0.05$).

Differently from previous results (see Table 3), Grade 1 text comprehension significantly predicted spelling errors, but only the Phonologically Incorrect type ($\beta = -0.16$; $p < 0.05$).

### 3.5. Concurrent relations between text comprehension and the other measures

The influence of decoding and spelling skills on text comprehension was assessed separately for Grades 1 and 3 by means of two different hierarchical multiple regressions (performed with the SPSS 17 package) in which text comprehension was the outcome and reading errors, reading speed and spelling errors were the predictors. Since age at Grade 1 significantly correlated to text comprehension (see Appendix), it was always entered in the first step as a control variable. In order to examine the concurrent relation between decoding and text comprehension, we entered reading errors and reading speed simultaneously in the same block, given that in transparent orthographic contexts reading accuracy alone is not a reliable indicator of effective decoding of print.

**Table 3**
Multivariate multiple regression analyses assessing longitudinal relationships between Grade 1 and Grade 3 reading and spelling measures.

| Independent variables (Grade 1) | Dependent variables (Grade 3) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Text comprehension | | Reading errors | | Reading speed (syll/min) | | Spelling errors | |
| | *B* (S.E.) | $\beta$ | *B* (S.E.) | $\beta$ | *B* (S.E.) | $\beta$ | *B* (S.E.) | $\beta$ |
| Text comprehension | 0.154 (0.061) | 0.197* | 0.002 (0.046) | 0.004 | −2.797 (2.109) | −0.107 | −0.034 (0.034) | −0.065 |
| Reading errors | −0.328 (0.140) | −0.229* | 0.139 (0.105) | 0.135 | −2.543 (4.820) | −0.053 | 0.291 (0.078) | 0.300*** |
| Reading speed (syll/min) | 0.004 (0.005) | 0.083 | −0.011 (0.004) | −0.298** | 0.532 (0.178) | 0.297** | 0.002 (0.003) | 0.050 |
| Spelling errors | −0.137 (0.115) | −0.113 | 0.069 (0.086) | 0.079 | −9.357 (3.953) | −0.230* | 0.393 (0.064) | 0.480*** |

S.E. = standard error. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

**Table 4**
Multivariate multiple regression analyses assessing longitudinal relationships between Grade 1 and Grade 3 reading and spelling measures. In this analysis the total number of spelling errors is replaced with the number of PI and SM & DC spelling errors.

| Independent variables (Grade 1) | Dependent variables (Grade 3) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Text comprehension | | Reading errors | | Reading speed (syll/min) | | PI spelling errors | | SM & DC spelling errors | |
| | *B* (S.E.) | $\beta$ | *B* (S.E.) | $\beta$ | *B* (S.E.) | $\beta$ | *B* (S.E.) | $\beta$ | *B* (S.E.) | $\beta$ |
| Text comprehension | 0.157 (0.062) | 0.202* | 0.006 (0.046) | 0.010 | −3.078 (2.126) | −0.118 | −0.075 (0.034) | −0.164* | 0.047 (0.034) | 0.103 |
| Reading errors | −0.323 (0.146) | −0.225* | 0.136 (0.109) | 0.131 | −1.117 (4.990) | −0.023 | 0.306 (0.080) | 0.366*** | 0.155 (0.081) | 0.184° |
| Reading speed (syll/min) | 0.006 (0.005) | 0.119 | −0.011 (0.004) | −0.285** | 0.573 (0.185) | 0.320** | 0.003 (0.003) | 0.096 | −0.001 (0.003) | −0.020 |
| PI spelling errors | −0.122 (0.120) | −0.099 | 0.054 (0.089) | 0.060 | −9.931 (4.105) | −0.240* | 0.167 (0.066) | 0.231* | 0.231 (0.066) | 0.317*** |
| SM & DC spelling errors | 0.056 (0.151) | 0.033 | 0.071 (0.112) | 0.058 | −1.313 (5.146) | −0.023 | 0.002 (0.083) | 0.002 | 0.237 (0.083) | 0.237** |

S.E. = standard error; PI = phonologically incorrect; SM & DC = errors on stress mark and doubled consonants.
°$p = 0.054$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Separate contributions of reading accuracy and reading speed were measured by means of $\beta$ values.

Two different models were then performed. In Model A the first block was age, the second spelling errors and the third decoding (that is reading errors and reading speed scores). In Model B the first block was age, the second decoding and the third spelling errors. Model A tests if decoding contributes significant variance to text comprehension after controlling for spelling (unique contribution). Model B tests if spelling uniquely contributes significant variance to text comprehension beyond the effects of reading accuracy and reading speed. In order to explore whether the two types of spelling errors differently influence text comprehension, we recalculated Model B, replacing, in the third block, the total number of spelling errors with the number of Phonologically Incorrect and Stress Mark & Doubled Consonants spelling errors. The two error scores were entered simultaneously in the same block and their unique contributions to text comprehension were assessed by means of $\beta$ values.

The results of hierarchical multiple regression analyses are reported in Table 5. The unique contribution of each block is represented by $R^2$ change ($\Delta R^2$) whereas $\beta$ value refers to the unique contribution of each single predictor when entering the corresponding block. In the lower part of the table results for Phonologically Incorrect spelling errors and Stress Mark & Doubled Consonants type are reported; only the third block of Model B is shown since the results for Blocks 1 and 2 are the same as the results regarding the total number of spelling errors.

In the analyses involving the total number of spelling errors as predictor, the proportion of variance ($R^2$) of text comprehension accounted for by all the predictors was 0.28 in Grade 1 and 0.22 in Grade 3; both $R^2$ values were significant with $p < 0.001$. Age accounted for significant variance to text comprehension only in Grade 1 ($\beta = 0.160$; $p < 0.05$).

After controlling for age in Model A (Block 2), spelling explained significant variance of text comprehension in both Grade 1 and Grade 3 (21.3% and 19.4% respectively; $p < 0.001$). After controlling for age in Model B (Block 2) also decoding explained significant variance of text comprehension in both grades (22.5% and 13.0% respectively; $p < 0.001$). Although all the contributions were significant, the comparison between Grade 1 and Grade 3 percentages showed that the influence of decoding on text comprehension decreases from Grade 1 to Grade 3 and that the influence of spelling on text comprehension is more stable than the influence of decoding. This pattern of results is in agreement with results for English-speaking children (e.g. Berninger et al., 2002; Mehta et al., 2005; Storch & Whitehurst, 2002).

An inspection of the results concerning the unique contributions of decoding and spelling when entered in the last block (Block 3) confirmed and deepened the pattern of results described in the previous paragraph. In fact after controlling for age and spelling (Model A) the unique contribution of decoding (Block 3) was significant in Grade 1 (4.7%; $p < 0.01$) and only approached significance in Grade 3 (2.8%; $p = 0.053$). After controlling for age and decoding (Model B) spelling (Block 3) explained an additional significant unique variance of text comprehension in both Grade 1 (3.5%; $p < 0.01$) and Grade 3 (9.2%; $p < 0.001$). These results add a new piece of information on the *relative* influences of decoding and spelling on text comprehension, as the effect of decoding became non-significant in Grade 3 whereas the (relative) influence of spelling increased from Grade 1 to Grade 3.

We would like to emphasize that the bivariate correlations of spelling with both reading accuracy and reading speed (see

**Table 5**
Hierarchical regression analyses assessing concurrent relationships between text comprehension and the other reading and spelling measures. Model B was recalculated by replacing the total spelling score with the number of PI and SM & DC spelling errors (Block 3): the results are shown in the lower part of the table.

| | Steps | Concurrent predictors | Dependent variable: text comprehension | | | |
|---|---|---|---|---|---|---|
| | | | Grade 1 | | Grade 3 | |
| | | | $\beta$ | $\Delta R^2$ | $\beta$ | $\Delta R^2$ |
| Model A | Block 1 | Age | 0.160* | 0.026* | 0.038 | 0.001 |
| | Block 2 | Spelling errors | −0.463*** | 0.213*** | −0.441*** | 0.194*** |
| | Block 3 | Reading errors | −0.168 | 0.047** | −0.049 | 0.028° |
| | | Reading speed (syll/min) | 0.160 | | 0.166* | |
| Model B | Block 1 | Age | 0.160* | 0.026* | 0.038 | 0.001 |
| | Block 2 | Reading errors | −0.266** | 0.225*** | −0.151° | 0.130*** |
| | | Reading speed (syll/min) | 0.256** | | 0.274** | |
| | Block 3 | Spelling errors | −0.257** | 0.035** | −0.351*** | 0.092*** |
| Model B | Block 3 | PI spelling errors | −0.242** | 0.046** | −0.318*** | 0.111*** |
| | | SM & DC spelling errors | −0.088 | | −0.092 | |

$\beta$ = Beta values of the single predictors in the block, at the corresponding step; $\Delta R^2 = R^2$ change after entering the block; PI = phonologically incorrect; SM & DC = errors on stress mark and doubled consonants. °$p < 0.06$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Appendix) were higher in Grade 1 (0.63 and 0.63 respectively) than in Grade 3 (0.41 and 0.42 respectively). This pattern of results suggests that decoding and spelling are strongly linked in an earlier stage (according to Fletcher-Flinn et al., 2004) and become more independent of one another in later stages.

When the unique contributions of reading accuracy and reading speed to text comprehension are considered separately ($\beta$ values in Model A) the contribution of reading accuracy was non-significant in both grades whereas the contribution of reading speed was significant only in Grade 3 ($\beta = -0.166$; $p < 0.05$).

When Phonologically Incorrect and Stress Mark & Doubled Consonants spelling scores were entered in the third block instead of the total number of spelling errors, the proportion of variance ($R^2$) of text comprehension accounted for by all the predictors was 0.30 in Grade 1 and 0.24 in Grade 3; both $R^2$ values were significant with $p < 0.001$. After age and decoding had been accounted for, only Phonologically Incorrect spelling errors significantly contributed to text comprehension in both Grade 1 ($\beta = -0.242$; $p < 0.01$) and Grade 3 ($\beta = -0.318$; $p < 0.001$).

Unexpectedly, we found that the separate contributions of reading accuracy and reading speed to text comprehension were non-significant in Grade 1. This result is in contrast with the literature on transparent as well as opaque orthographies (see Sections 1.3 and 1.4). However we also found that reading errors and reading speed were highly correlated in Grade 1 (−0.67 see Appendix). The weak separate unique contributions of the two measures to text comprehension are therefore likely to be owed to the high proportion of explained variance of text comprehension shared between reading accuracy and reading speed. In fact when the two scores were entered together their combined contribution to text comprehension was significant. The correlation between reading accuracy and reading speed was lower in Grade 3 (−0.39 see Appendix) showing that the two skills are more independent at this stage.

### 3.6. Direct and indirect effects of Grade 1 reading and spelling measures on Grade 3 text comprehension: a comprehensive path analysis

In the previous paragraphs, the longitudinal (Section 3.4) and concurrent (Section 3.5) predictors of Grade 3 text comprehension have been examined separately in a explorative fashion, and taking into account only the direct effects of predictors on the outcome(s). A further step involves looking at the longitudinal and concurrent relationships between Grade 3 text comprehension and the other variables simultaneously, and including direct and indirect effects. Our lens was primarily focused on the indirect effects of Grade 1 spelling and reading speed on Grade 3 text comprehension, via Grade 3 predictors. Multiple regression results indicated that Grade 1 spelling and reading speed did not account for unique variance in Grade 3 text comprehension (see Section 3.4). However, Grade 1 spelling significantly predicted both Grade 3 spelling and reading speed, and these skills in turn affected Grade 3 text comprehension. Given this pattern of results it may be argued that an indirect connection would exist between Grade 1 spelling and Grade 3 text comprehension, via Grade 3 reading speed and spelling. Analogously, Grade 1 reading speed may indirectly affect text comprehension, via Grade 3 reading speed.

Therefore, in order to examine the direct and indirect relationships among variables, a path analysis was carried out using LISREL 8.3 (Joreskög & Sorböm, 1999). Based on results of regression analyses, a model was set up as in Fig. 2.

Grade 1 reading and spelling measures were considered as exogenous variables, Grade 3 reading and spelling measures as outcomes. The longitudinal paths were specified according to multivariate regression results (see Fig. 2). Therefore we freely estimated the autoregressive paths from Grade 1 reading comprehension, reading speed and spelling to the same measures in Grade 3 along with the following direct effects: Grade 1 reading errors on both Grade 3 text comprehension and spelling; Grade 1 reading speed on Grade 3 reading errors; Grade 1 spelling on Grade 3 reading speed. The other longitudinal paths were fixed to zero. Based on results on concurrent predictors of Grade 3 text comprehension (Section 3.5), we also included in the model the paths from both Grade 3 spelling and reading speed to Grade 3 text comprehension and we fixed to zero the direct effect of Grade 3 reading accuracy to Grade 3 text comprehension. Overall model fit was evaluated with chi-square statistic, together with the following indices: the root mean square error of approximation (RMSEA); the comparative fit index (CFI); the non-normed fit index (NNFI); and the standardized mean square residual (standardized-RMR), as suggested by Hu and Bentler (1999).

The model provided a good fit to the data ($\chi^2(12) = 19.87$, $p = 0.07$; RMSEA = 0.06; NNFI = 0.98; CFI = 0.98; standardized-RMR = 0.05), with all paths in the model statistically significant. Adding the direct paths that the model specifies to be zero did not improve model fit and even when freely estimated, these paths were all non-significant. Thus, the direct effects of Grade 1 spelling and reading speed to Grade 3 text comprehension were both non-significant. Indirect effects estimates for the model (Fig. 2) indicated that Grade 1 spelling had a significant ($p < 0.01$) standardized indirect effect of −0.11 on Grade 3 text comprehension, of which −0.08 (73% of the indirect effect) was transmitted via Grade 3 spelling and −0.03 (27% of the indirect effect) via Grade 3 reading speed. The indirect effect of Grade 1 reading speed on Grade 3 text comprehension, via Grade 3 reading speed, showed a trend towards significance (standardized indirect effect = 0.05, $p = 0.052$). Path analysis results also confirmed the importance of Grade 1 reading errors as predictor of later text comprehension: indeed parameter estimates for the model (Fig. 2) indicated that Grade 1 reading errors influenced directly Grade 3 text comprehension, beyond shared variance with Grade 1 reading comprehension and Grade 3 reading speed and spelling measures. The indirect effect of Grade 1 reading errors on Grade 3 text comprehension (via Grade 3 spelling) did not approach significance.

## 4. General discussion

In this study we were concerned with concurrent and longitudinal relationships between literacy skills in a sample of Italian children observed at the end of Grade 1 and then again at the end of Grade 3.

As regards unique longitudinal contributions of literacy skills, we showed that Grade 1 reading speed (but not reading accuracy) was a significant predictor of individual differences in Grade 3 literacy (Hypothesis 1a) and that reading speed was more stable than reading accuracy (Hypothesis 1b). Moreover, we found that Grade 1 reading speed was the strongest predictor of Grade 3 literacy and the only significant predictor of Grade 3 reading accuracy. This confirms and extends the importance of this school-entry measure for the prediction of later academic performance in transparent orthographic contexts (e.g. Landerl & Wimmer, 2008). Unexpectedly, spelling was the most stable among the measures considered in this study and contributed to the discrimination between Grade 3 High and Low Literacy groups.

Although Grade 1 reading accuracy did not significantly contribute to the prediction of a global score of later literacy, it significantly predicted both later text comprehension (as in Muter et al., 2004; Seigneuric & Ehrlich, 2005) and spelling accuracy in the regression and path analyses. Thus, for Italian children, inaccurate reading in Grade 1 could be a predictor for later, more specific, difficulties in literacy acquisition. Factors such as motivation or home literacy environment (e.g. Manolitsis, Georgiou, & Parrila, 2011;

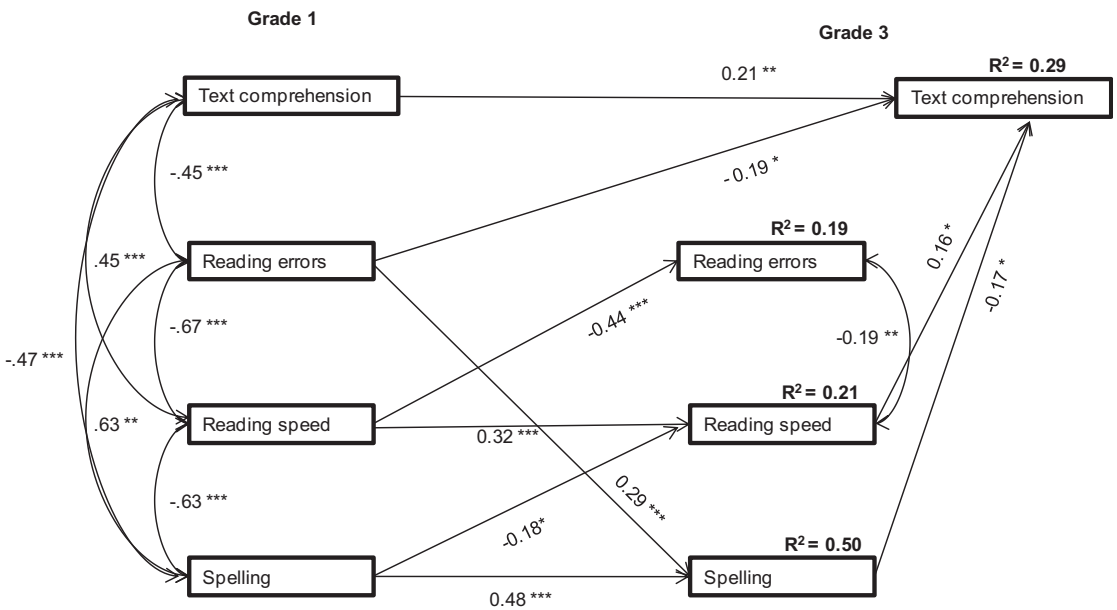


**Fig. 2.** Path model of the direct and indirect effects of Grade 1 reading and spelling measures on Grade 3 text comprehension.* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Manolitsis et al., 2009) – that were not analyzed in our study – might have contributed to the longitudinal influence of Grade 1 reading accuracy on later spelling and text comprehension.

We also found a longitudinal asymmetry between reading accuracy and spelling accuracy (Hypothesis 2a); in fact, Grade 1 spelling errors did not significantly predict Grade 3 reading errors. This asymmetry mostly involved Phonologically Incorrect spelling errors, which are generated by ineffective learning of phoneme–grapheme conversion rules (Hypothesis 2b). This pattern of results is in agreement with Wimmer and Landerl (1997) and Caravolas (2004): when sound-to-print consistency is higher than print-to-sound consistency, correct phonological reading enhances spelling development, especially in early grades, when spelling mainly depends on application of phoneme–grapheme rules.

Focussing on the concurrent prediction of text comprehension we found, consistently with results on opaque orthographic contexts (e.g. Storch & Whitehurst, 2002), that the contribution of decoding was stronger in Grade 1 than in Grade 3 (Hypothesis 3a). Conversely, spelling was significantly related to text comprehension in both grades (Hypothesis 3b). The contribution of reading speed was significant only in Grade 3, and so Hypothesis 3c was only partially confirmed. This pattern of results shows that the relationships between spelling, decoding and text comprehension changed across grades. To explain the characteristics of this change, we first consider the relationships among literacy skills in Grade 1.

Reading accuracy, reading speed and spelling were strongly linked to one another in Grade 1. Studies on transparent orthographies (Caravolas, 2004; Orsolini et al., 2006) showed that both reading and spelling are mainly based on the application of grapheme–phoneme and phoneme–grapheme conversion rules at this stage. According to these findings we obtained that Phonologically Incorrect errors, which are generated by weak learning of phoneme–grapheme conversion rules, were the most frequent among Grade 1 spelling errors. Concurrent regression analyses also showed that decoding and spelling uniquely and significantly affected Grade 1 reading comprehension.

How could the conversion processes involved in spelling, along with those involved in reading, affect Grade 1 text comprehension? The high correlation between decoding and spelling suggests a reciprocal influence between grapheme–phoneme and phoneme–grapheme conversion processes in Grade 1 (see also Fletcher-Flinn et al., 2004). We can speculate that the effective acquisition of phoneme–grapheme conversion rules strengthens grapheme–phoneme processes (and vice versa), thus improving accurate reading. Following LaBerge and Samuels (1974), accurate reading in turn leaves more attentional resources available for comprehension. There is also some evidence that text comprehension in Grade 1 is significantly linked not only with reading accuracy, but also with vocabulary knowledge (Seigneuric & Ehrlich, 2005). Therefore, the relationship between accurate reading and text comprehension at this stage might be mediated by vocabulary development.

Importantly, our speculation of a reciprocal influence between reading accuracy and spelling in Grade 1 is not in contrast with our longitudinal findings about the asymmetrical relationship between these abilities. It could be suggested that the association between reading and spelling changes over time, with a shifting from a reciprocal influence to an asymmetrical relationship. Future research is needed to disentangle this possibility and to deeply investigate when this shifting occurs.

Focussing on Grade 3 results, the correlation between reading accuracy and reading speed appeared to be lower than that observed in Grade 1. Moreover a significant relation between reading speed and text comprehension was shown in the concurrent regression analyses only in Grade 3. This pattern of results suggests that a lexically-driven word recognition, based on richer orthographic knowledge, helps older Italian children to quicken their reading (see also Orsolini et al., 2006; Zoccolotti et al., 2009), enhancing reading comprehension. Also Grade 3 effective spelling seems to be more dependent on orthographic knowledge compared to Grade 1, as Stress Mark and Doubled Consonants errors, owed to incomplete orthographic learning, were the most frequent among spelling errors in Grade 3.

Concurrent regression analyses also showed that Grade 3 text comprehension was significantly and uniquely predicted by Grade 3 spelling whereas the unique contribution of Grade 3 reading accuracy to text comprehension was non-significant. Furthermore, path analysis showed that Grade 3 text comprehension was indirectly influenced by Grade 1 spelling, via Grade 3 spelling and Grade 3 reading speed. This pattern of results can be explained focussing on the development of orthographic knowledge, its role

in reading speed and text comprehension, and its dependence on a self-teaching phonological process.

As mentioned in the introduction, the new version of the *self-teaching hypothesis* (Shahar-Yames & Share, 2008) emphasizes that spelling can favour the acquisition of word-specific orthographic representations better than reading. Since lexical orthographic knowledge is considered crucial for text comprehension as it improves more rapid lexically-driven word recognition (Apel, 2009), spelling accuracy is likely to promote text comprehension more than reading accuracy. This hypothesis is in agreement with the results we observed in Grade 3, where the unique contribution of spelling to text comprehension was significant whereas the unique contribution of reading accuracy was not. A link between lexical orthographic knowledge and rapid word recognition can also explain why Grade 1 spelling influenced Grade 3 reading speed which, in turn, improved Grade 3 text comprehension (see longitudinal regression and path analysis results). Our speculation is supported by Wood (2009) findings showing that lexical orthographic knowledge in Grade 3 influenced both word recognition and reading fluency in Grade 4 and that these two skills significantly improved text comprehension in the same grade.

Shahar-Yames and Share's (2008) hypothesis about the superiority of spelling in promoting orthographic knowledge can explain not only Grade 3 concurrent regression results, but also the longitudinal relationships observed in our study between reading errors and the different types of spelling errors. Grade 1 reading errors significantly predicted only Grade 3 Phonologically Incorrect spelling errors, which are generated by ineffective learning of phoneme–grapheme conversion rules. Grade 1 Phonologically Incorrect spelling errors, on the other hand, also significantly predicted Grade 3 Stress Mark and Doubled Consonants errors. Thus early difficulties with phoneme–grapheme conversion rules also negatively affect the development of lexical orthographic memories that, in turn, are less likely to feed the spelling process in Grade 3 with those word-specific representations required to apply stress or doubled consonants correctly.

It should be considered, however, that Shahar-Yames and Share's (2008) hypothesis about the superiority of spelling in promoting orthographic knowledge was developed examining Hebrew children performances. As Hebrew orthography, similarly to Italian, shows high regularity in reading but is less regular in spelling (Apel, 2009; Shahar-Yames & Share, 2008), it would be interesting to examine in orthographies with different characteristics (e.g. English) if spelling promotes orthographic knowledge and text comprehension more than reading.

Although we did not examine listening comprehension, our result regarding the trend in the relationship between text comprehension and decoding is in line with the *Simple View of Reading* (Gough & Tunmer, 1986). It states that reading comprehension (RC) is equal to the product of two separate components: decoding (D) and linguistic comprehension (C), that is the ability to interpret sentences and discourses presented orally. Research has shown that decoding and listening comprehension account for a large proportion of variance in reading comprehension and that the relative contribution of these components to the *Simple View of Reading* is subject to changes over time. In the early grades, reading comprehension is mostly explained by word-reading skills. As students move to more complicated reading materials in later grades, the contribution of listening comprehension increases, whereas the contribution of word decoding decreases (e.g., Adlof et al., 2006; Storch & Whitehurst, 2002). According to the *Simple View of Reading* we showed that the contribution of decoding to text comprehension decreased across grades (Hypothesis 3a). However we also showed that spelling significantly contributed to text comprehension in both grades (Hypothesis 3b), above and beyond the contribution of decoding. Therefore, at least at this stage, spelling accounts for some of the variance of text comprehension not accounted for by decoding. Furthermore we evidenced a significant longitudinal relationship between Grade 1 reading accuracy and Grade 3 text comprehension, thus also longitudinal relationships should be taken into account in a *Simple View of Reading*.

Our findings also have one important methodological implication. We evidenced that reading and spelling share common and significant variance in early grades. Shared variance, if not taken into account, can lead to misleading results. For example, it may falsely accentuate the relationship between one of the two measures and other abilities, or make indirect paths of association look direct. This suggests the importance of taking into account the relation between reading and spelling in further research on the cognitive correlates of literacy skills.

### 4.1. Limitations

The main limitation in our work is that we did not take into account other linguistic variables that influence text comprehension, such as vocabulary or listening comprehension (Müller & Brady, 2001; Verhoeven & van Leeuwe, 2008). We believe that this limitation does not invalidate our findings although taking into account vocabulary would have better clarified how reading and spelling influence text comprehension. Another limitation is that our explanation about the nature of the relationship between spelling and text comprehension is only speculative. Since we did not expect spelling to influence text comprehension so deeply, we did not plan in advance any specific test to evaluate orthographic knowledge. The great attrition rate in our data might be considered a limitation, however the reasons for attrition were not owed to the subjects characteristics or differences in literacy skills. For this reason we are confident that our longitudinal sample can be viewed as a random sub-sample of the total sample assessed in Grade 1.

### 4.2. Educational implications

We should like to emphasize the main educational implications of our findings. First, slow reading is not only an important characteristic of reading difficulties in children learning a transparent orthography but is also a reliable longitudinal predictor of later low literacy skills. Second, early difficulties in acquiring grapheme–phoneme conversion rules might be linked to later difficulties with spelling and text comprehension. Third, early difficulties with phoneme–grapheme conversion rules are not only associated with later spelling difficulties but also predict later slow reading that, in turn, negatively influences text comprehension.

Thus our results suggest the importance of focussing early educational interventions on both reading and writing, with a focus on practising both grapheme–phoneme and phoneme–grapheme conversion rules. Treating the underlying skills that may affect early reading speed should also be on the agenda of educational psychologists. However we agree with the Paris (2005; Paris et al., 2005) statement that accurate and fluent reading is a necessary but not sufficient condition for text comprehension, therefore early educational interventions should also focus on both vocabulary skills and language comprehension.

In conclusion, our findings provide further evidence that the consistency of an orthography affects the characteristics of reading and spelling acquisition and add new data suggesting that also the relationships between the two skills are affected by orthographic consistency. Given the explorative nature of our work, more research is needed to support our findings, considering transparent orthographic contexts different from Italian as well as investigating the possible mediators of reading-spelling interplay (e.g. orthographic knowledge and vocabulary).

## Appendix

Inter-correlations between all the measures considered in the study.

| | | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Age – G1 | | | | | | | | | | | | | |
| 2. | Text comprehension – G1 | 0.16* | | | | | | | | | | | | |
| 3. | Reading errors – G1 | −0.12 | −0.45*** | | | | | | | | | | | |
| 4. | Reading speed – G1 | 0.04 | 0.44*** | −0.67*** | | | | | | | | | | |
| 5. | Spelling errors (tot) – G1 | −0.08 | −0.47*** | 0.63*** | −0.63*** | | | | | | | | | |
| 6. | PI spelling errors – G1 | −0.09 | −0.48*** | 0.65*** | −0.55*** | 0.91*** | | | | | | | | |
| 7. | SM & DC errors – G1 | −0.06 | −0.38*** | 0.44*** | −0.59*** | 0.80*** | 0.55*** | | | | | | | |
| 8. | Text comprehension – G3 | 0.09 | 0.39*** | −0.44*** | 0.39*** | −0.40*** | −0.39*** | −0.27*** | | | | | | |
| 9. | Reading errors – G3 | −0.02 | −0.22** | 0.38*** | −0.44*** | 0.35*** | 0.33*** | 0.31*** | −0.26*** | | | | | |
| 10. | Reading speed – G3 | −0.02 | 0.16* | −0.35*** | 0.43*** | −0.40*** | −0.39*** | −0.31*** | 0.33*** | −0.39*** | | | | |
| 11. | Spelling errors (tot) – G3 | −0.05 | −0.40*** | 0.60*** | −0.48*** | 0.67*** | 0.65*** | 0.49*** | −0.44*** | 0.41*** | −0.42*** | | | |
| 12. | PC spelling errors – G3 | 0.03 | −0.22** | 0.22** | −0.25*** | 0.30*** | 0.28*** | 0.21** | −0.19* | 0.31*** | −0.25*** | 0.45*** | | |
| 13. | PI spelling errors – G3 | −0.12 | −0.40*** | 0.52*** | −0.35*** | 0.46*** | 0.49*** | 0.30*** | −0.42*** | 0.32*** | −0.26*** | 0.80*** | 0.27*** | |
| 14. | SM & DC errors – G3 | 0.03 | −0.23** | 0.46*** | −0.41*** | 0.58*** | 0.53*** | 0.47*** | −0.31*** | 0.30*** | −0.41*** | 0.84*** | 0.27*** | 0.40*** |

G1 = Grade 1; G3 = Grade 3; PC = phonologically correct; PI = phonologically incorrect; SM & DC = spelling errors on stress mark and doubled consonants.
$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

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