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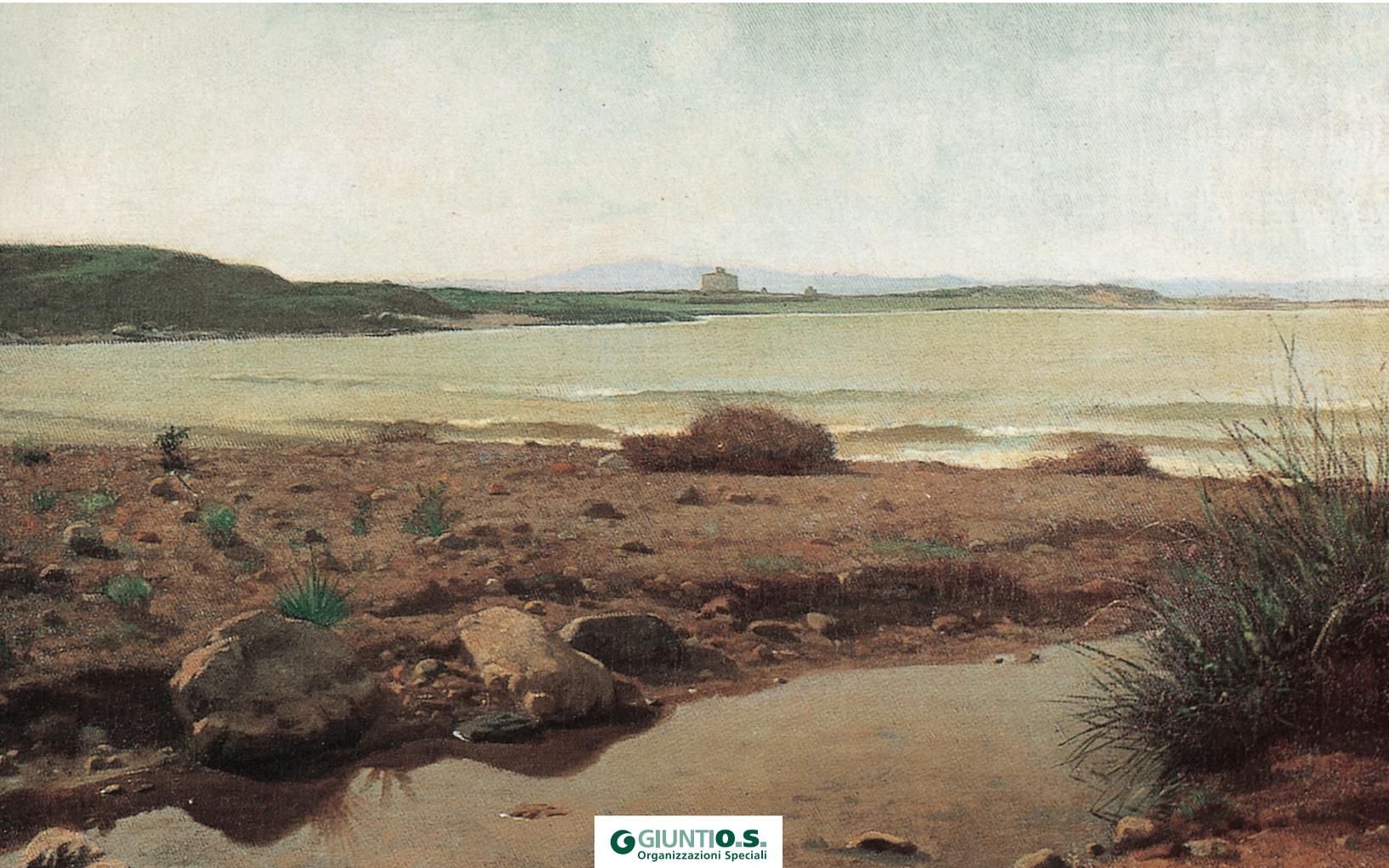
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Research



Experiences & Tools



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The evolution of the reading profile in children with developmental dyslexia in a regular orthographies

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✎ **ABSTRACT.** Le ricerche dimostrano che la dislessia nelle lingue ad ortografia trasparente evolve, nel corso del tempo, in maniera differente per i parametri rapidità e accuratezza, in favore di quest'ultima. Scopo dello studio è quello di esaminare l'evoluzione dell'abilità di lettura lungo l'arco della scolarità obbligatoria, dalla scuola primaria a quella secondaria di secondo grado, nell'ortografia italiana. Inoltre, ha l'obiettivo di verificare se esistono differenti traiettorie evolutive in relazione alla severità del disturbo di lettura. Lo studio è stato condotto su un campione di 71 bambini dislessici italiani, secondo i criteri diagnostici stabiliti dal manuale diagnostico ICD-10 e dalla Consensus Conference. Il campione è stato suddiviso in due gruppi: un gruppo di dislessici lievi (n=36) e un gruppo di confronto di dislessici medio-severi (n=35). Tutti i partecipanti sono stati valutati almeno due volte in due diversi livelli scolastici. I confronti sono stati effettuati sulle prestazioni medie in ogni grado scolastico. I risultati rivelano traiettorie evolutive della capacità di lettura simili nel corso del tempo, in favore del gruppo dei dislessici lievi. I dislessici medio-severi mostrano un andamento che non è lineare nel corso del tempo, con un peggioramento nel corso dell'ultimo anno scolastico analizzato (1a secondaria di secondo grado), mentre il gruppo dei lievi mostrano un incremento costante nel tempo. Per quanto riguarda il parametro rapidità, entrambi i gruppi mostrano un incremento maggiore nella lettura delle parole e del testo, mentre rivelano un incremento minore nella decodifica delle non parole.

✎ **SUMMARY.** Several researchers have demonstrated that dyslexia develops differently in shallow orthographies in terms of accuracy and speed. In fact, slow reading speed persists and accuracy improves. The aim of this study is to investigate the evolution of the specific reading disorder over the years of compulsory education, from primary to upper secondary school. Furthermore, it has the aim to verify if there are different evolutionary trajectories of reading skills in relation to the severity of the disorder. The study was carried out on 71 Italian dyslexic children, according to the diagnostic criteria established by the diagnostic manual ICD – 10 and the Consensus Conference. Two groups were selected: children who met criteria for mild dyslexia (mild dyslexics, with n=36) and a comparison group of moderate-severe dyslexics (n=35). All participants were tested at least twice in two different school grades. Comparisons were made on the average performances in each school grade. The results reveal similar patterns of growth over time in reading ability, with the mild dyslexics group outperforming the moderate-severe dyslexics group. The performance trajectory for the moderate-severe dyslexics shows some plateaus and a decrease in performances in the last year analyzed (1st upper secondary school) while the trajectory for the mild dyslexics always show increases in performances. All subjects show a steady increase in word and text reading speed and a slower improvement in pseudo-word decoding.

Keywords: *Developmental dyslexia, Reading, Regular orthographies*

INTRODUCTION

Most of the experts agree that dyslexia is a lifelong condition that can spontaneously improve and change in form (Tressoldi, Stella & Faggella, 2001). Several researchers agree that in consistent languages (characterized by high grapheme-phoneme correspondence) the critical sign of dyslexia concerns the speed in decoding (“speed dyslexia”, Wimmer, 1993).

The slowness in reading persists, especially in the reading of pseudowords where there is a lower increase in speed that seems to reach a ceiling (“ceiling effect”) at the end of the secondary school level; in the reading of the text and of the words, instead, it occurs the lexical effect (Shaywitz et al., 1999; Stella, Savelli, Scorza & Morlini, 2010; Tressoldi et al., 2001).

As regards instead the parameter accuracy, several authors show that the time lead to an increase in the accuracy of the master such that the gap between dyslexics and typical readers tends to shrink; we also know that in the transparent languages there is a lower number of errors compared to opaque languages (Holopainen, Ahonen & Lyytinen, 2001; Jimenez, 2012; Paulesu et al., 2001; Tressoldi et al., 2001).

The longitudinal study seems to be a valid tool to explain the evolution of dyslexia. In fact, such analyses identify the parameters that remain unvaried during the developmental phases, recognizing the predictive signs of the severity and the persistence of the disorder. These investigations are also useful to establish suitable rehabilitation plans for dyslexics. The Connecticut Longitudinal Study (Shaywitz et al., 1999) is one of the first perspectives on the evolution of the disorder. The in-depth exploratory and follow-up study of dyslexic children into adulthood is carried out on a sample of 445 children. The results of the study show that slow reading speed and phonological deficits persist during adolescence and adulthood, whereas decoding accuracy improves.

Other longitudinal studies aim to understand why some children are vulnerable to the acquisition of reading skills, such as the the Jyväskylä Longitudinal Study of Dyslexia (Lyytinen et al., 2006) and the Dutch Dyslexia Programme (Van der Leij et al., 2013).

The Jyväskylä Longitudinal Study followed 200 Finnish children from birth to school age. Half of these children had a family history of reading problems and were considered at risk for dyslexia; the other half were not at risk. They have identified four subgroups with differential trajectories to early reading. The results revealed that there are at least three

troubled routes along which a child may ultimately encounter difficulties in reading acquisition. The most explicit routes are characterized by problems in either phonological awareness, naming speed, or letter knowledge problems that increase in severity with age (Lyytinen et al., 2006).

The Dutch Dyslexia instead analyzed a sample of 180 children with a familiar risk of dyslexia and a comparison group of 120 children without familiar risk of dyslexia and followed them from 2 months old up to 9 years. With regard to precursors of reading disability, the children were divided into three groups: familiar risk (FR) children with and without dyslexia, and controls. The results showed that regarding reading development, the FR children with dyslexia read less fluently since first grade onwards than the other two groups; the reading fluency of the FR children without dyslexia, instead, was at an intermediate level between the other groups and, furthermore, their word reading fluency gradually improved relative to the controls. By fifth grade, they had managed to catch up on word reading fluency, although they were still significantly slower than the controls on pseudowords reading fluency, indicating problems with word reading when sublexical orthographic knowledge is required (Van der Leij & Van Daal, 1999; Van der Leij et al., 2013).

The regular orthographic system of the Italian language makes it relatively easy to learn to read and write. In fact, reading and writing skills consolidate in the first two school years and children seem to be able to read 95% of a list of high-frequency words, at the end of primary education. (Scorza et al., 2015; Zoccolotti, De Luca, Di Filippo, Judica & Martelli, 2008). Tressoldi (1996) finds an average increase of .5 syllables per second during each year until the end of the lower secondary school, while the average text reading speed is 6 syllables per second.

Other works (Arina, Iervolino & Stella, 2013; Stella & Tintoni, 2007) show that decoding speed and accuracy still evolve after lower secondary school. There is a significant and persistent difference between dyslexics and normal readers in terms of decoding speed. Both groups improve their reading speed every year but variations in performance across grades can become more marked. Normal readers increase their reading speed by .5 syllables per second in both words and text reading and dyslexics by .3 syllables/second, less than their peers do (Tressoldi et al., 2001). In fact, the reading speed of dyslexic students attending the third year at lower secondary school is equal to that of normal readers in early literacy. The analyzed performances reveal that the lexical effect (Ziegler,

Perry, Ma-Wyatt, Ladner & Schulte-Korne, 2003; Zoccolotti & Burani, 2010) influence text reading and the words superiority effect can influence pseudowords reading.

However, many studies reveal that the progress is strictly related to the level of severity detected during infancy, as mild dyslexics improve more than severe ones (Lami, Palmieri, Solimando & Pizzoli, 2008).

The longitudinal study by Stella et al. (2010) is conducted on a sample of 35 dyslexic children. This study demonstrates that mild dyslexics (17 subjects) improve consistently in text and word reading in upper secondary school. However, their speed improvement is markedly slower in pseudowords decoding and they do not make any progress in more advanced education levels. It is possible to imagine a sort of “ceiling effect” on speed improvement when decoding new words, similarly to what happens to adult compensated dyslexics.

The group of severe dyslexics (17 subjects) shows a much lower increase in reading speed compared to the group of mild dyslexics.

In text and word-reading tests, the severe dyslexics in upper secondary school have a reading speed comparable to that of normal readers attending class 3 at primary school. In pseudo-word reading, they present further difficulties and they do not even reach the level of normal readers in class 2. Severe dyslexics increase to 1 syllable per second during the entire period of compulsory education (Stella et al., 2010).

In terms of accuracy, there are not substantial differences between mild and severe dyslexics. Both groups show notable improvements, which are very close to the normative values of the population (Lami et al., 2008; Stella et al., 2010). Campanini, Battafarano & Iozzino (2010), however, reach a different conclusion in their transversal study conducted on 291 dyslexic young subjects. They show, in fact, that the number of errors rises considerably in all classes and even tends to increase with education, leaving a widening gap between normal readers and dyslexics. Tucci, Savoia, Merella & Tressoldi (2013) replicate Stella’s study (Tressoldi et al. 2001). They examine the natural evolution of reading acquisition in 57 dyslexic young subjects using a transversal-longitudinal study. The results show that there is still a gap between dyslexics and normal readers in terms of speed as school grades increase. Regarding accuracy, the number of errors tends to decrease in dyslexics but it is still quite high compared to that of their normal-reading peers, especially in the words and text-reading tasks.

Many authors agree that in a regular orthography like Italian, time produces an increase in accuracy control that reduces the differences between normal readers and dyslexics. In terms of decoding speed, there is instead a broad gap between both groups, despite a slight increase. These findings show that the critical parameter for dyslexia in regular orthographies is decoding speed. Hence, we can speak of speed dyslexia (Wimmer, 1993).

The Italian studies are consistent with those on the evolution of the disorder carried out in other countries with regular orthographies. Most of the international research on the developmental dyslexia, in fact, suggest that the reading difficulties encountered are mainly two, depending on the kind of orthography. In fact, phoneme-grapheme decoding accuracy is significantly low in opaque orthographies, whereas reading speed is slow in shallow orthographies (Scortichini; Gasperini, Scorza, Boni & Stella, 2015). For example, Wimmer & Mayringer (2001; 2002) conduct studies on German, Leinonen et al. (2001) and Holopainen et al. (2001) on Finnish, and Serrano & Defior (2008), Jimenez (2012) and Jimenez & Hernandez-Valle (2000) on Spanish. They show that children have problems both in speed and accuracy in pseudowords decoding. Undheim (2009) diagnoses a sample of Norwegians with dyslexia at the age of ten. Conducting a follow-up study of the same sample at 16-23 years old, he notices that all reading times are much higher than the normative values especially in pseudo-word decoding. Recently Caravolas (Caravolas, Lervag, Defior, Malkova & Hulme, 2013) has conducted a longitudinal study on reading acquisition in English, Spanish and Czech. The results show a slower development of reading abilities in English compared to other two orthographies that are more consistent.

Goswami and Ziegler (2005; 2006) explain the relationship between reading development and linguistic context. The Grain Size Theory demonstrates that there are substantial discrepancies between different spelling systems. In some languages such as English or Danish many different sounds correspond to a single grapheme, while, in orthographies like Italian or Spanish, a single grapheme corresponds to a single phoneme (Coltheart, Rastle, Perry, Langdon & Ziegler, 2001; Scortichini et al., 2015).

Therefore children learning to read in orthographies considered opaque make more mistakes and are less fluent compared to children reading regular orthographies. The accuracy parameter refers to a cross-cultural study conducted on 36 dyslexics from France, England and Italy (12 for each

country) compared with a control group of 36 subjects equally distributed. All participants are administered both phonological short-term memory tasks and reading tests. In the short-term memory tests, the groups show a deficit, whereas the Italian dyslexic group achieve the best score in accuracy. The authors conclude that there is a universal neurocognitive base for dyslexia and that the orthographic structure of the languages rather than dyslexia causes disparities between the reading abilities (Paulesu et al., 2001).

In conclusion, slow reading speed seems to be the main problem in adolescence, whereas accuracy tends to improve with education. Subjects suffering from developmental dyslexia (DD) present a phonological deficit; this is why they read more slowly and less fluently than normal readers do. It is then essential for them to have more time to activate all the cognitive and linguistic (semantic-lexical) abilities, which compensate for the lack of decoding skills (Tucci & Tressoldi, 2009). The neuropsychological profile of adult dyslexics is particularly attractive because it explains the evolution of the disorder over time, as it affects other aspects of the cognitive function besides the reading difficulties. Kinsbourne (1991) carries out a study on 34 adults distributed in two groups: “severe” and “compensated” dyslexics. Severe dyslexics show deficits in verbal fluency, in rapid automatic naming, in verbal acquisition tests and temporal judgements. Compensated dyslexics perform poorly, instead, in rapid automatic naming and verbal fluency (Ghidoni, 2011). Hatcher, Snowling & Griffiths (2002) assess a sample of 23 dyslexics, whose average age is 25 years. The authors note that they perform poorly in pseudowords decoding, spelling, digit span, and writing speed. The personal experiences of the subjects reveal difficulties in manipulating data and organizing their work (Martino et al., 2011). Maughan et al. (2009) have conducted a significant follow-up study on a group of forty years old dyslexics, thirty years after the diagnosis of the disorder. The subjects still show persistent spelling deficits affecting the daily reading and writing activities (Ghidoni, 2011). Re, Tressoldi, Cornoldi & Lucangeli (2011) carry out a study on 104 university students from Padova. The results reveal that the average reading speed was four syllables per second, which was adequate for studying autonomously. However, old difficulties re-emerged under stress conditions (such as articulatory suppression) affecting the quality of the learning. Recently, Ciuffo et al. (2014) have conducted a study on silent reading, which is the standard reading form in teens, university students and

adults. The results suggest that both normal readers and dyslexics improve their speed in silent reading rather than in loud reading. The improvement achieved by the dyslexic group, though, is clearly inferior to that of normal readers. It is plausible to suppose the presence of a structural deficit in automated reading, which is the process that promotes lexical access and facilitates the reading activity. These data confirm that there is a striking difference between dyslexics and normal readers in silent reading mode. In fact, dyslexics’ top reading speed is 6.15 syllables/second, whereas the control group score 10.75 syllables/second. The results also emphasize the reduced speed difference between the loud reading test (4.89 syllables/second) and the silent reading test. The comparison reveals that there is a specific deficit in the recognition process, which is the basic structure of the decoding activity. This cognitive deficiency seems to be the cause of decoding issues rather than the verbal articulation of the written words required in loud reading.

AIMS AND SCOPE

The present study aims to investigate the evolution of the specific reading disorder over the years of compulsory education from primary to upper secondary school. Furthermore, it has the aim to verify if there are different evolutionary trajectories of reading skills in relation to the severity of the reading disorder.

The research examines a sample of subjects diagnosed with dyslexia between the second and the third class of primary education. All participants are re-assessed over the years of compulsory education at least twice and no more than seven times. Comparisons are made on the average performances in each school grade. A proportion of the sample in each school year is dropped from the subsequent year and replaced with different children. Therefore, each pair of samples coming from two different school grades have some children in common and some other children present in only one of the two samples. The study aims to analyze the development of reading abilities in dyslexics, through a series of reading tests, and to characterize and compare the pattern of growth over time in word, pseudowords and text reading. Two groups of participants are identified, according to the seriousness of the disorder (mild and moderate-severe), in order to examine the different evolution of the reading abilities.

PARTECIPANTS

The selected 71 participants are children enrolled in compulsory school, coming from different regions of Italy and diagnosed with dyslexia between the second and the third class of primary education. The medical diagnoses of the subjects comply with the diagnostic manual ICD-10 and the Consensus Conference (2007; 2011), in agreement with the discrepancy criterion between reading ability and general intelligence. All subjects were required to reach a performance QI and a Verbal QI >85¹ (Verbal QI score obtained in the PPVT-R, 2000) and were assessed at least twice in two different school years, to evaluate their reading disorder. Assessments have been done during the period 1998-2015. Children were recruited from patients consulting a private professional studio. Of the seventy-one participants, 47 are males and 24 females. This interesting detail is consistent with the hypothesis that dyslexia affects more males than females. In fact, the risk of developing ED is 2.5 times higher in males than females (Consensus Conference, 2011). Another remarkable aspect is that there are three couples of brothers of which two twins.

PROCEDURES AND TOOLS

All reading profiles are evaluated with the following tools:

- Words and pseudowords reading tests from the Battery for the evaluation of developmental dyslexia and dysorthography, (Sartori, Job & Tressoldi, 1995, 2007). Tests differ in features in each class and are adequate to the educational level of the child.
- MT reading tests for children in primary and lower secondary school (Cornoldi & Colpo, 1995, 2012) and MT advanced reading test (Cornoldi et al., 2010) for students in upper secondary education.

The reading ability is evaluated considering speed and accuracy. Speed is measured both with the overall reading time (in seconds) and the number of syllables per seconds read (fluency). For comparisons between these two measures and a comprehensive discussion about the problem of measuring reading speed in reading tests we refer to Cornoldi & Colpo (1995, 2012), Lorusso, Toraldo & Cattaneo (2006), Morlini,

Stella & Scorza (2013, 2014, 2015).

Accuracy is measured with the number of errors made in all three tests.

All subjects are divided into the following two groups according to the reading performance in the first assessment:

- Mild ED group: if the reading time, in seconds, in the list of words, falls between the second and third standard deviation.
- Moderate-severe ED group: if the reading time, in seconds, in the list of words, falls between the second and third standard deviation.

METHOD

Comparisons are made on the average performances in each school grade. The study used a rotating sample design with participants interviewed at least twice during the years of compulsory education. A proportion of the sample in each school year is dropped from the subsequent year and replaced with different children. Therefore, each pair of samples coming from two different school grades have some children in common and some other children present in only one of the two samples.

RESULTS

Reading Development: comparison between dyslexics and control group

First, the average pattern of all participants affected with a reading disorder is compared to the normative values of the tests. The curve of growth in performances is similar in all the three tasks (words, pseudowords and text reading) and reveals a substantial gap between the dyslexics' decoding ability and that of their normal-reading peers. The gap increases as the level of educational attainment increases. The difference in performances between dyslexics and non-disabled children is greater in reading of the list of words. Figure 1 shows the decoding speed trend of the dyslexic subjects in words and pseudowords reading tasks in comparison with the control group. Figure 2 shows the decoding speed trend of the

¹ The tests used to assess the cognitive abilities are: the Raven's Progressive Matrices (CPM 47 ; SPM 38) and scales WISC - III (for the subjects assessed before the year 2012) and WISC-IV.

Figure 1 – Words and pseudowords reading speed: comparison between collected data for dyslexics and control values

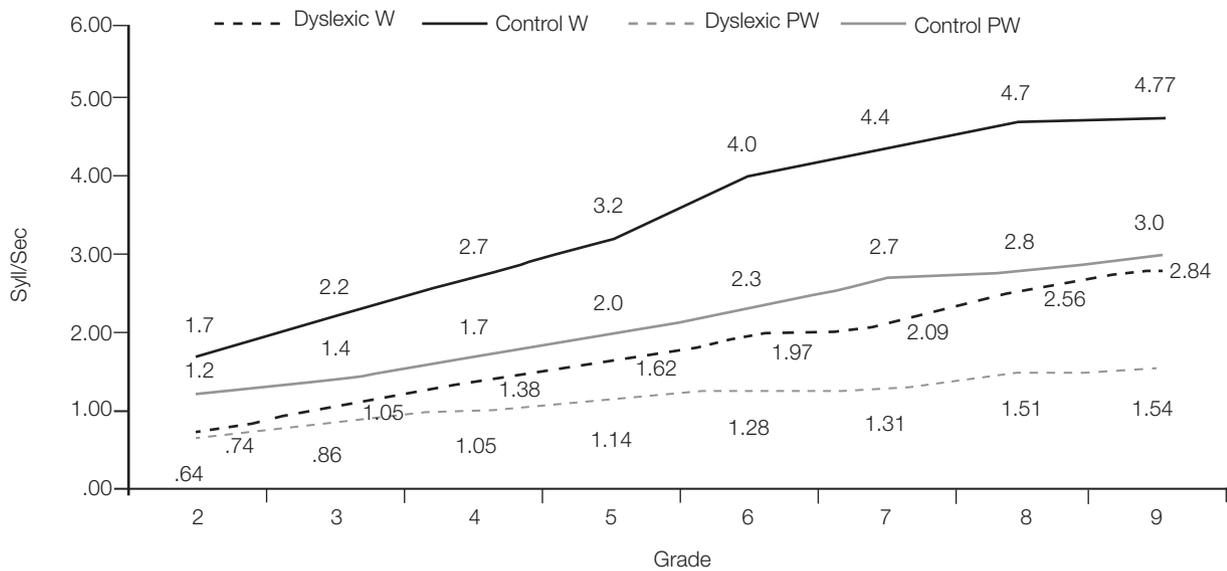
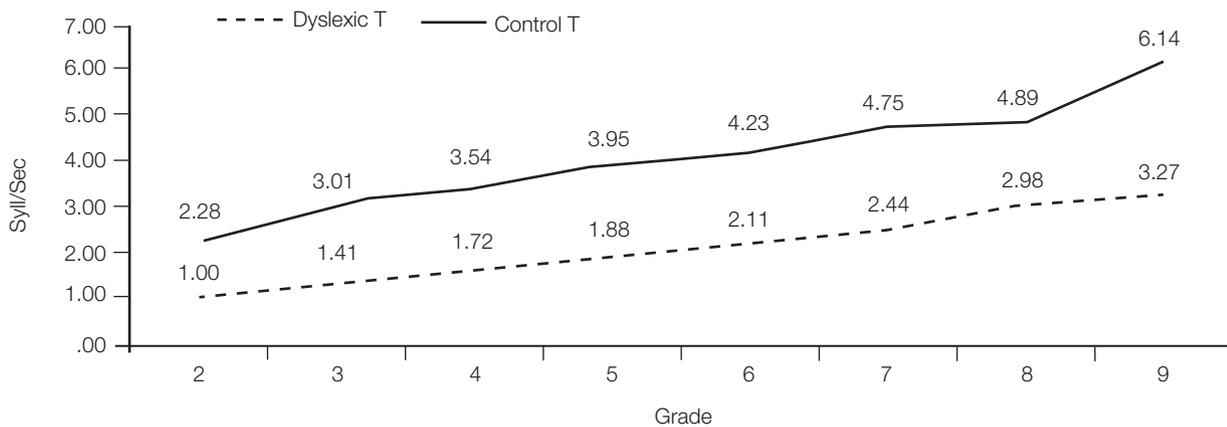


Figure 2 – Text reading speed: comparison between collected data for dyslexics and control values



dyslexic and non-dyslexics subjects in the text reading task. For the text reading task, the gap between disabled and non-disabled students tends to increase with education, as long as for the word and pseudowords reading tasks. Indeed, in the first year at upper secondary school, dyslexics read about 3.27 syllables per second, which are about half of the syllables read by a normal reader. The average rate of growth per year in reading the list of words is .29 syllables per second for dyslexics and .44 for the control group. The greatest increase occurs between class II and III of lower secondary school (.54 syllables/second) and the lower increase between class IV and

V of primary school (.16 syllables/second). In reading the list of pseudowords the average rate of growth per year is .12 syllables per second for dyslexics and .27 for the control group. In reading the text the average rate of growth is .31 syllables per second for dyslexics and .48 for the control group. The speed in reading the list of words seems to best separate disabled and nondisabled readers and to be the best predictor for dyslexia. The greater improvement in performances in words reading is probably due to the high frequency of the terms used. Decoding new words in the pseudo-word tests is obviously more challenging.

For what concern reading accuracy, the best performances and improvements are observed in the words reading test. In this test, dyslexics still keep improving their skill in the advanced educational stages, while in the other tests the curve of grow in the last few years have some plateaus or show increases in the number of errors. In pseudo-word reading, the improvement is less evident and the number of errors is quite high even in the advanced educational stages. The text-reading test reveals a nonlinear and non-monotonic trend over time. This trend confirms that text reading is the most difficult task for dyslexics. Figure 3 reports averages errors in words, pseudowords and text reading for dyslexics and the control values of the tests.

Analyzing averages values for speed and accuracy in each school year, we may draw some conclusions:

- Reading skill in dyslexics improves both in accuracy and in speed, during the eight analyzed years of compulsory education.
- In text reading, both the speed and the number of errors increase with education. This may be due to the fact that the difficulty in reading the text affects more the accuracy of reading (number of errors) than the speed (syllables per second read) and the higher the reading speed, the greater the number of errors. The result of this study is consistent with the available literature on the subject (Stella et al.,

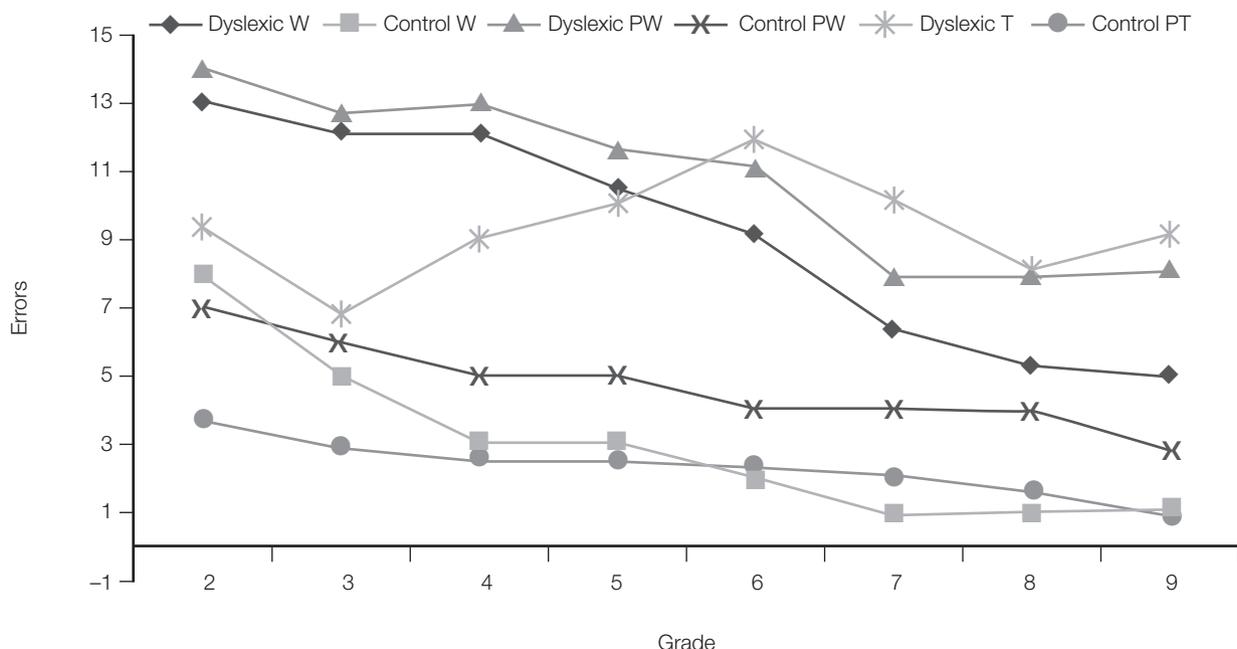
2010; Tressoldi, 1996; Tressoldi et al. 2001).

- Speed, in the word reading test, seems to be the most reliable predictive indicator of the future development of the reading ability. In word reading, the reading speed of dyslexic children increase by .29 syllable/seconds per year. In pseudo-word reading, the average improvement is .12 syllables/second per year. The greatest increase occurs between class II and III of primary school (.22 syllables/second) and between class II and III of lower secondary school (.20). A minimal improvement is shown between lower and upper secondary school (.03 syllables/second). This pattern confirms the “ceiling effect”.

Reading Development: comparison between mild and severe dyslexics

Another aim of this research is the comparison of the dyslexics according to the severity of their diagnosis. In order to model changes in reading over the time span of the study, we have interpolated a linear regression line on the yearly average values for the groups of mild dyslexics and severe dyslexics and for all dyslexics (average curve). Because of the relatively small sample sizes of mild and severe dyslexics in each year, we have chosen a linear rather than a quadratic or nonparametric

Figure 3 – Errors in words, pseudowords and text reading: comparison between collected data for dyslexics and control values



function. The F-test in all regression lines, except for the line interpolating the number of errors in the text reading, show a very good fit: all p -values are smaller than .001 and indicate that the slope of the regression line is significantly different from zero, even for $\alpha = .001$ level of the test. The only pattern that cannot be interpolated with a straight line is the pattern relative to the number of errors in the text reading. Comparing the slopes of the curves, we see that in each measure (syllables per seconds, seconds and number of errors) and in each test (words, pseudowords and text) mild dyslexics demonstrate

the highest level of improvement in reading performances, the average group demonstrate the next highest level and the severe dyslexic the lower level.

As regards the reading of the words, Figure 4, 5 and 6 show the development of speed and accuracy in the words reading test, over the period examined.

Regarding speed, performances of severe dyslexics still remain quite distant from the average in the last years. A severe grade 9 dyslexic reads 1.78 syllables per second and reaches the reading speed of a grade 2 normal reader (1.70

Figure 4 – Words reading speed for dyslexics: comparison between mild and moderate-severe dyslexics

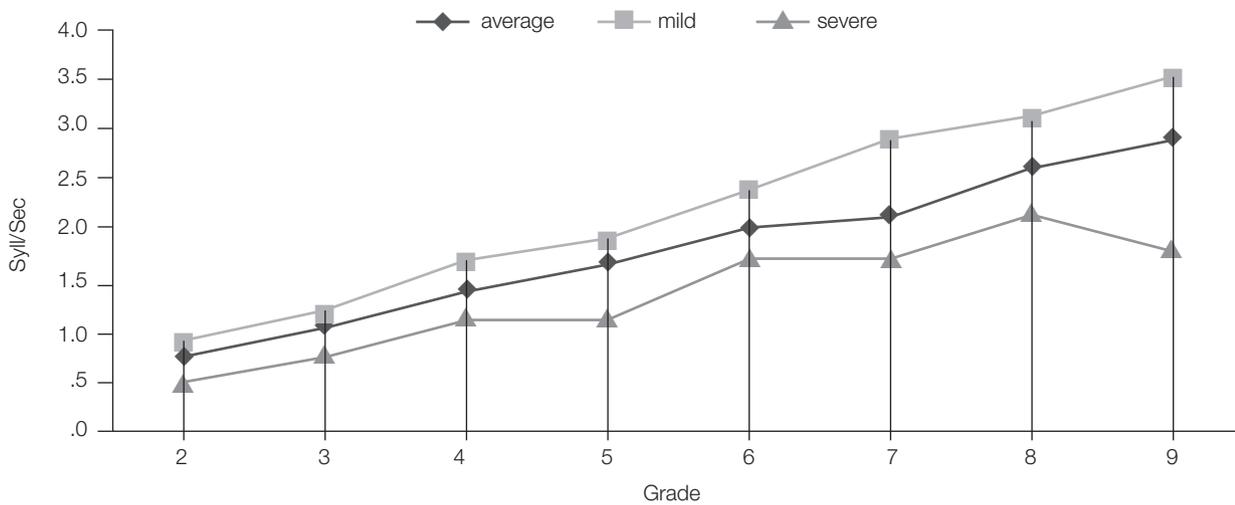


Figure 5 – Words reading fluency for dyslexics: comparison between mild and moderate-severe dyslexics

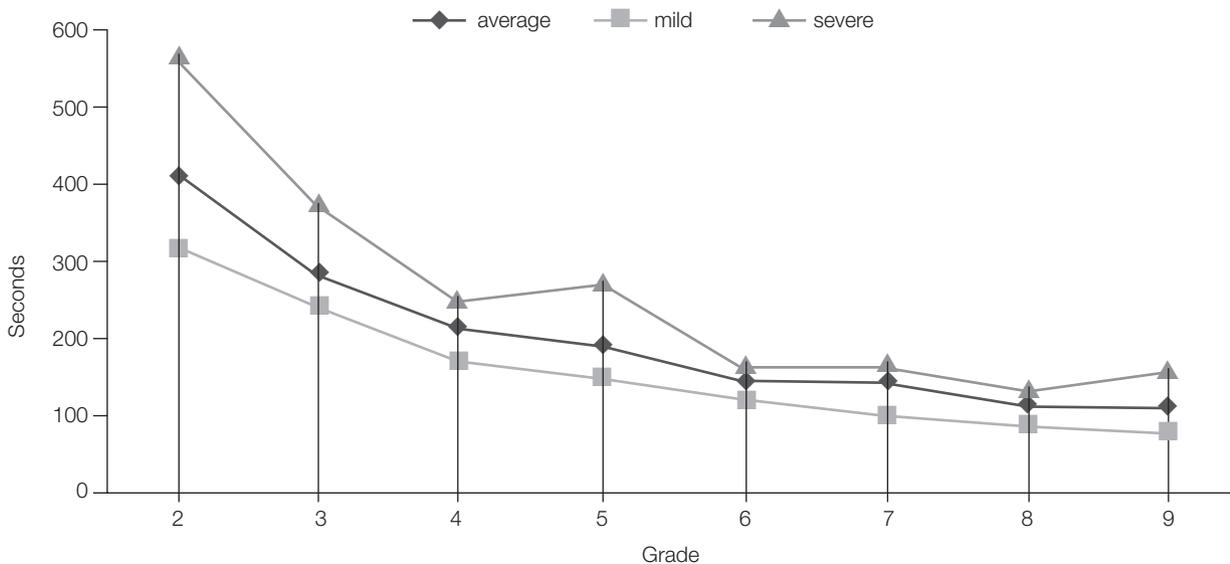
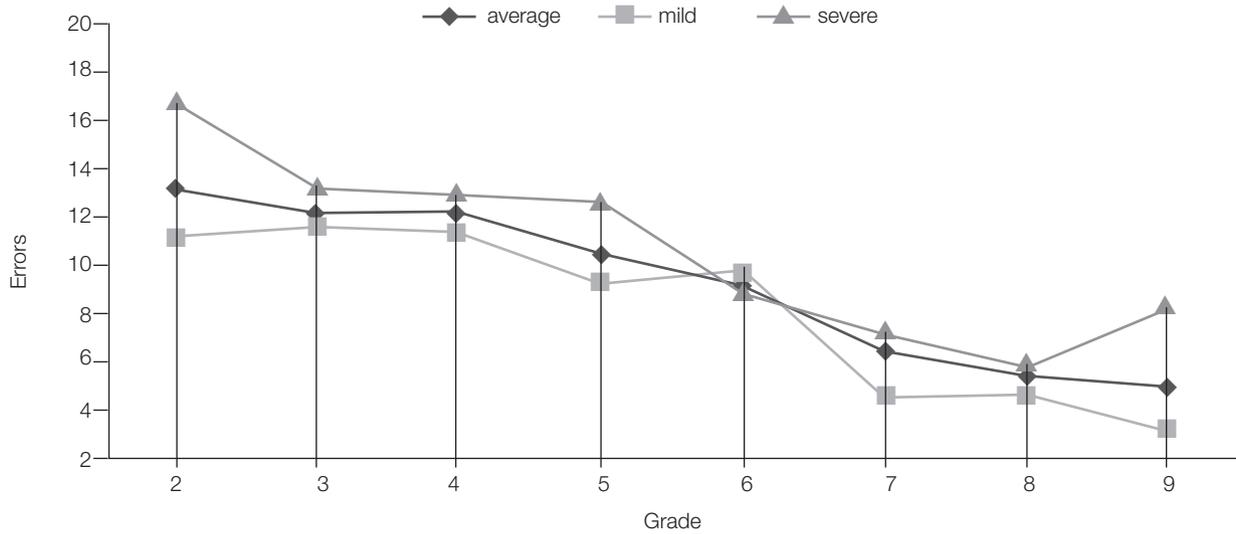


Figure 6 – Accuracy in reading words for dyslexics: comparison between mild and moderate-severe dyslexics



syllables per second). The group of mild dyslexics shows annual increases of performances while severe dyslexics in some years show constant or even decreasing performances.

Considering accuracy, in all grades, except for grade 6, mild dyslexic students make fewer errors than the severe ones and their overall performance tend to improve more rapidly, especially in upper secondary school when the distance from the normal readers seems to decrease and the distance between mild and severe dyslexics reach the maximum value.

As regards the reading of the pseudowords, Figure 7, 8 and 9 show the development of speed and accuracy in the pseudowords reading test, over the period examined.

Severe dyslexics present a substantial distance from the average, confirming their phonological difficulties. Results show that a grade 9 student who reads about 1.14 syllables/seconds does not even reach the average speed of the grade 2 control group (1.20 syllables/seconds) after eight years of schooling.

In pseudowords reading speed, the curve of growth for mild dyslexics is smoother than the curve of growth for severe disabled students. Severe disabled students show greater differences in performances between years and also decreases in performances in some years. Regarding accuracy, the pattern is not monotone both for mild and severe dyslexics and the differences in performances are less evident.

Both groups make more mistakes in this test rather than in the words reading test. Mild dyslexics make a steady and remarkable improvement compared to the group of severe dyslexics, especially in the advanced educational years where

they reduce the distance from the control group.

Finally, as regards the reading of the text, Figure 10 and 11 show the development of speed and accuracy in the text reading test, over the period examined.

Mild dyslexics improve their decoding speed by .39 syllables/second, whereas severe dyslexics by .23. This result confirms a minor improvement in the decoding ability that creates a considerable gap between dyslexics and normal readers (increase by .55 syllables /sec). The distance between performances of mild and severe dyslexics increases in the last school years.

Regarding accuracy, both groups show a nonlinear trend, making more mistakes between primary and lower secondary school. However, mild dyslexics make fewer mistakes than the severe ones do. The cause of the great number of errors is probably the increasing length and difficulty of the chosen texts. As long as for speed, the distance between performances of mild and severe dyslexics increases in the last school years.

Moreover, another interesting finding concerns the characteristics of the increase detected in the decoding speed of the words and the text in the dyslexic groups. Both groups show an almost identical increase in the speed of reading of the words and the text (.37 syllables/second in the words and .39 syllables/second in the text for mild dyslexics; .22 syllables/second in the words and .23 syllables/second in the text for the moderate-severe dyslexics) contrary to the typical readers that show a significantly higher average progress in the text reading compared to words reading (.55 syllables/

Figure 7 – Pseudowords reading speed for dyslexics: comparison between mild and moderate-severe dyslexics

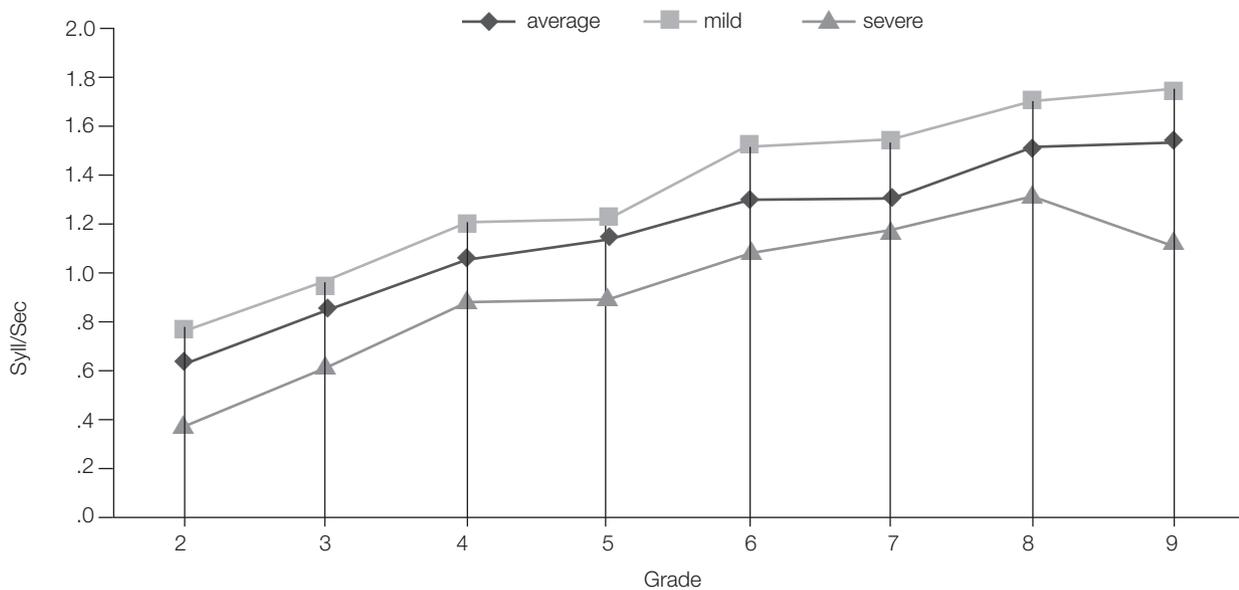
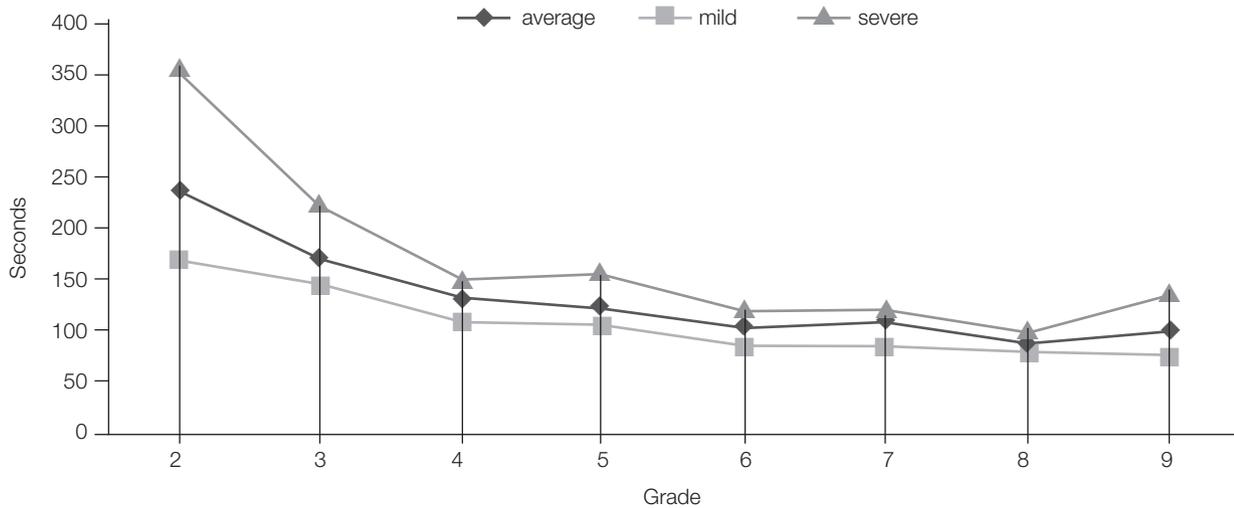


Figure 8 – Pseudoword reading fluency for dyslexics: comparison between mild and moderate-severe dyslexics

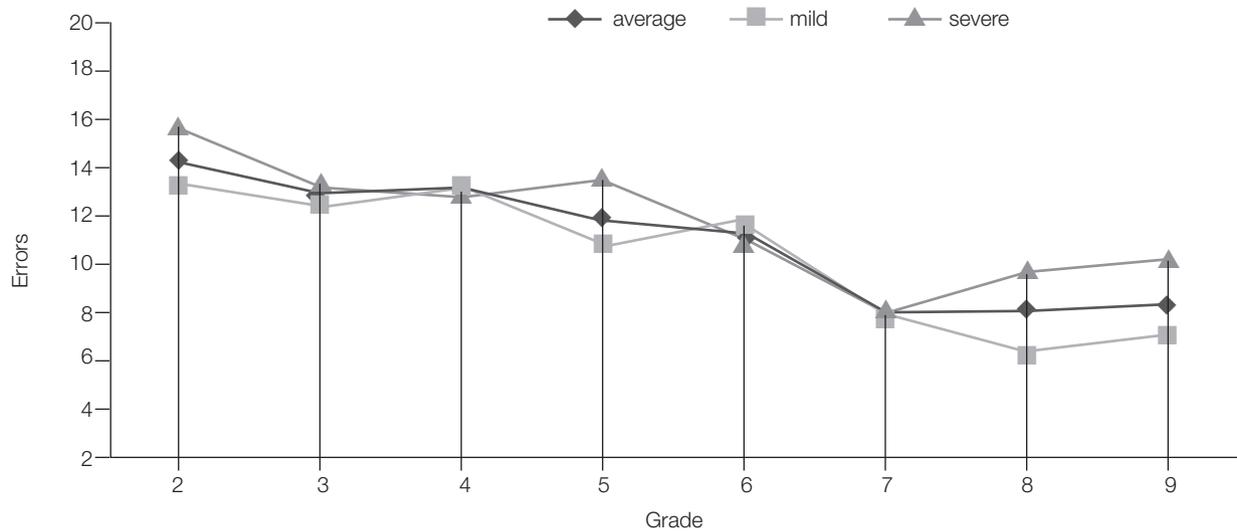


second in the text and .44 syllables/second in the words; Sartori et al., 1995, 2007).

The lack of advantage in the text reading than the words reading could be attributed to two different factors: inefficiency in some aspects of visual processing (crowding effect; Martelli, Di Filippo, Spinelli & Zoccolotti, 2009 - or preview effect – McCandliss, 2012) or weakness of some linguistic processes. In this last case, given that there is a difference

in the speed increase between words and pseudowords, the inefficiency does not concern lexical aspects, but it regards the facilitation that comes from the “linguistic knowledge” (Leonard, 2009). In fact, it would produce some advantages in lexical access deriving from implicit knowledge gain about utterance construction (Stella, 2013). With regards to the visual processing, there should be considered the advantages derived from the manipulation of text spacing (Zorzi et. al.,

Figure 9 – Accuracy in reading pseudowords for dyslexics: comparison between mild and moderate-severe dyslexics



2012), while the linguistic processes imply a revision of the role of lexical factors in reading process, by distinguishing lexical aspects (word recognition) from semantic-syntactic ones (related to the textual structure).

Table 1 reports the slope, the value of R^2 and the p -value for the F test in the regression lines fitted on the yearly average values for the groups of mild dyslexics and severe dyslexics and for all dyslexics (average regression line). The accuracy in reading the text is the only measurement that cannot be fitted by a linear line. All other measurements show a very good fit (all p -values are smaller than .01 and most of them are smaller than .001).

Regarding speed, the average yearly improvement (given by the slope of the regression line) of mild dyslexics is higher than the average improvement of moderate-severe dyslexics, in all tasks. Mild dyslexics have an annual improvement of .37 syllables per second in reading the words, .14 syllables per second in reading pseudowords and .39 syllables per second in reading the text. Moderate-severe dyslexics have an improvement of .22, .12 and .23 syllables per second, respectively. In words and text reading, both groups have a higher improvement than in pseudowords reading: this confirms the “ceiling effect” in decoding new words (Stella et al., 2010).

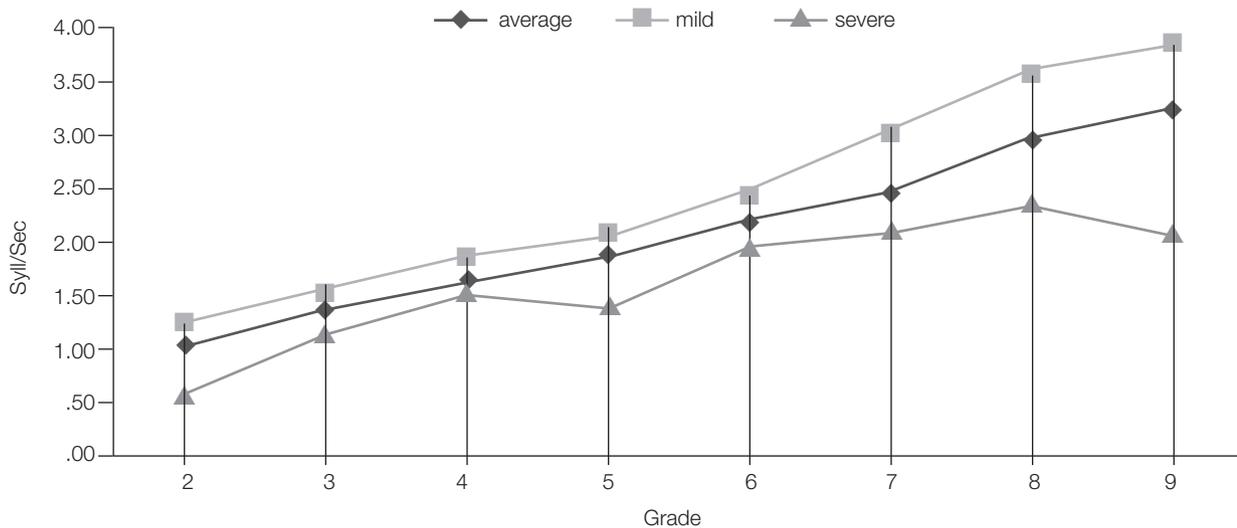
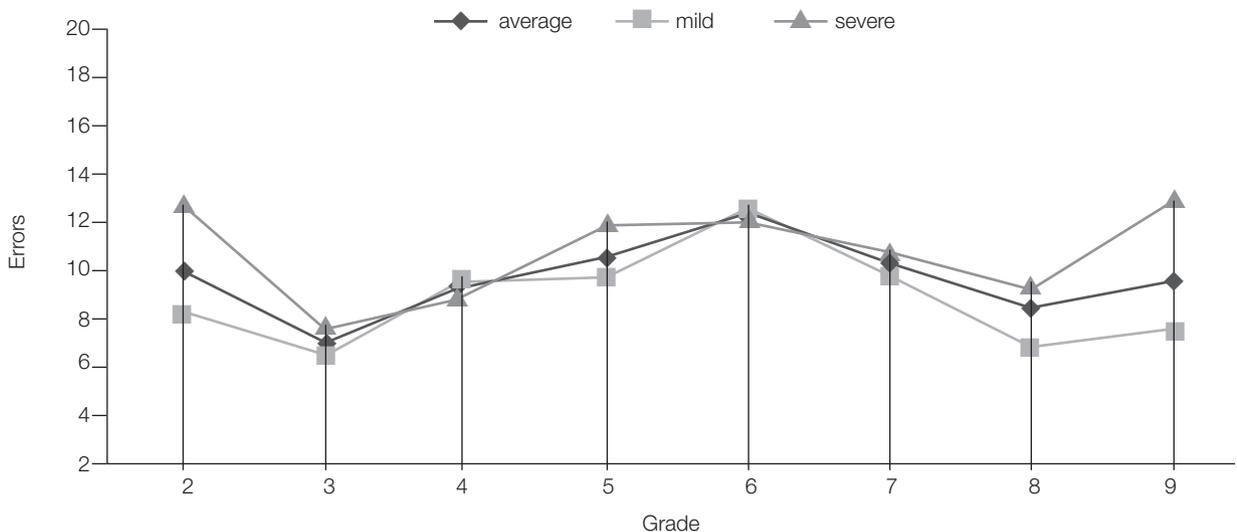
In reading fluency (measured with the time in seconds), severe dyslexics show a higher yearly improvement than mild dyslexics while in reading accuracy severe dyslexics improve better in words reading and mild dyslexics improve better in pseudowords reading.

DISCUSSION

Results of this study show that both the decoding speed and the decoding accuracy in dyslexics improves over the years of compulsory education. However, the gap between dyslexic and typical readers remains and that the decoding deficits recorded a different development in relation to the two parameters of speed and accuracy, in favor of the latter.

In shallow orthographies, Wimmer (1993) has noted how the reading disorder is much more evident in terms of speed and accuracy. Sometimes reading can be completely or almost accurate but is typically slow, with many pauses and hesitations. The data of our sample confirm the findings in international studies (Holopainen et al., 2001; Jimenez, 2012; Paulesu et al., 2001; Shaywitz et al., 1999; Van der Leij et al., 2013) and other Italian studies (Stella et al., 2010; Tressoldi et al., 2001; Tucci et al., 2013): the gap between dyslexic and typical readers is progressively reduced for the parameter speed reading of words and text, while in the pseudo-word occurs less increase (“ceiling effect”). The accuracy improves instead to a greater extent in the words, while in the text and in the pseudowords, while showing an improving trend, the distance between dyslexic and typical readers remains greater.

One view is that children are phonologically accurate but that their phonological processing is slow. Mayringer & Wimmer (2000) reported that Austrian dyslexic children are consistently deficient in a pseudowords learning task.

Figure 10 – Text reading speed for dyslexics: comparison between mild and moderate-severe dyslexics**Figure 11** – Accuracy in reading text for dyslexics: comparison between mild and moderate-severe dyslexics

Furthermore, pseudowords reading speed was more impaired in dyslexics than in age- or reading-matched controls than word reading speed. In other words, this view assumes that the reading defect is based on “phonological inefficiency” (Di Filippo, De Luca, Judica, Spinelli & Zoccolotti, 2006).

In relation to the severity of the reading disorder, the data of this study allow to make further considerations on the development of dyslexia. As regards the speed parameter, the data showed that there is a statistically significant difference between the annual average increase of dyslexic mild and medium - severe both in the reading of the words

and of the text. In the reading of pseudowords instead there is no statistically significant difference: the phonological decoding seems to be more compromised, regardless of the characteristics of the language system (Rack, Snowling & Olson, 1992; Vellutino, Fletcher, Snowling & Scanlon, 2004; Ziegler et al., 2003).

It is known that what allows a fast and fluid reading is the use of their lexical knowledge and this applies to both languages in regular spelling, such as Italian, which for the opaque like English. The lexicality effect, the frequency effect, the effect of imaginability and the effect of age of acquisition

Table 1 – Estimated parameters for the linear interpolating functions

	Words reading speed	Pseudo words reading speed	Text reading speed	Words reading fluency	Pseudo words reading fluency	Accuracy in reading words	Accuracy in reading pseudo words	Accuracy in reading text
<i>AVERAGE REGRESSION LINE FOR DISLEXICS</i>								
Slope	.294	.125	.312	−37.498	−17.045	−1.304	−.964	.120
R²	.994	.963	.983	.840	.747	.952	.901	.037
p-value (test F)	.000	.000	.000	.001	.006	.000	.000	.647
<i>REGRESSION LINE FOR MILD DISLEXICS</i>								
Slope	.369	.141	.391	−31.466	−12.736	−1.314	−1.088	.019
R²	.994	.961	.980	.878	.853	.863	.837	.001
p-value (test F)	.000	.000	.000	.001	.001	.001	.001	.953
<i>REGRESSION LINE FOR MODERATE-SEVERE DYSLEXICS</i>								
Slope	.217	.115	.229	−51.960	−26.599	−1.376	−.863	.182
R²	.883	.840	.869	.767	.628	.850	.736	.061
p-value (test F)	.000	.000	.000	.001	.006	.000	.000	.000
<i>DIFFERENCES BETWEEN THE SLOPE FOR MILD DISLEXICS AND THE SLOPE FOR MODERATE-SEVERE DYSLEXICS</i>								
	.153	.025	.161	20.494	13.863	.062	−.226	−.162

are documented since the early years of schooling (Tressoldi, 1996; Zoccolotti & Burani, 2010). For example, the effect of lexicality and stimulus length was studied by Di Filippo et al. (2006) in 32 third- and fourth-grade Italian dyslexics and in 86 age-matched controls and the results were analyzed in terms of raw reaction time (RT). The results showed that in terms of RT, dyslexics exhibited a larger difference between words and pseudowords (lexicality effect) and between short and long stimuli (length effect) than typical readers. This pattern indicates that stimulus length has a specific role in Italian dyslexics' reading deficit. Ziegler et al. (2003) investigated reading characteristics of dyslexic children in

regular and less regular orthographies and he considered three critical marker effects of the reading process such as effects of lexicality, length and large orthographic units. The results of this study clearly showed that the similarities between orthographies were far bigger than their differences: English and German dyslexics exhibited a reading speed deficit, a nonword reading deficit and an extremely slow and serial phonological decoding mechanism. These problems were of similar size across orthographies and persisted. The bottleneck of the dyslexic children in both countries seems to lie in the establishment of basic phonological recoding procedures. (Ziegler et al., 2003).

In addition, the results of this study have shown that the average annual increase in decoding speed in the reading of pseudowords of mild and medium - severe dyslexic is not statistically significant. This data confirms the available literature (Rack et al., 1992; Van den Broeck & Geudens, 2012; Ziegler et al., 2003). In fact, the size of the phonological decoding deficit can be estimated by comparing the difference between word and pseudo-word reading across different groups of readers. The words were read faster and more accurately than pseudowords (Rack et al., 1992; Ziegler et al., 2003). The deficit of pseudowords then it would seem not only characterize as dyslexia regardless of the language system, but it would seem the core deficits even in milder forms of dyslexia. In addition, some studies highlight how even the dyslexic adults compensated continue to experience difficulties in this task (Ghidoni, 2011; Hatcher et al., 2002; Martino et al., 2011).

As for the accuracy parameter, the dyslexic group mild improves constantly both in the reading of the words and of pseudowords, thereby reducing their distance from the average, while in the reading of the text show a trend that is not linear. This trend may depend on the increasing length and greater linguistic complexity of the tracks to read. It can therefore be assumed that increasing the reading speed will also increase the number of errors committed.

The group of medium - severe dyslexic instead shows a non-linear trend in all proposed stimuli. Based on these data it is possible to assume that the severity of the reading disorder affects the correctness greater extent than in the mild dyslexic group.

LIMITATION AND FUTURE RESEARCH

An important limitation of this study concerns the distribution of the sample that does not cover all the classes of the secondary school, but only the first class (level 9). So, this distribution does not allowed to make a comparison on the development of the reading ability throughout compulsory education. Clinically the results of this study permit some observations.

First of all, the slowness in decoding is a critical marker of the reading disorder.

Moreover, the absence of statistically significant difference between words reading and text reading supposes that lexical strategy does not sufficiently support reading decoding but

also some aspects of text comprehension. Considering that there are reported more comprehension difficulties in the upper secondary school respect to the primary school, it would be necessary to analyze if there is a relationship between the severity of the reading disorder and the text comprehension disorder. This is certainly a future aim of research.

CONCLUSIONS

The aim of this study was to investigate the evolution of reading disorder in the course of compulsory schooling and see if there are different evolutionary trajectories in relation to the severity of the reading disorder. The available literature on the subject considers dyslexia a persistent disorder over the years of compulsory education. In regular orthographies, the critical aspect is the reading speed (speed dyslexia; Wimmer, 1993), whereas decoding accuracy increases. In other words, children with dyslexia improve their overall reading ability, but they are still quite distant from their normal-reading peers

Data collected in the present work confirm that the gap between dyslexics and normal readers persists and that the decoding deficit concerning speed and accuracy develops differently. Reading remains a hard task for dyslexics since they show a slower and less fluent reading than typical readers.

There are differences also in the development of the reading profile between mild and severe dyslexics. The performance trajectory for the moderate-severe dyslexics shows some plateaus and a decrease in performances in the last year analyzed (1st upper secondary school) while the trajectory for the mild dyslexics always show increases in performances. All subjects show a steady increase in word and text reading speed and a slower improvement in pseudo-word decoding.

In terms of accuracy, the trajectory is less smooth. The mild dyslexics group outperforms the moderate-severe dyslexics only in some school years. In other years, the performances are similar.

These findings are consistent with those of other studies on the subject (Holopainen et al., 2001; Jimenez, 2012; Lyytinen et al., 2006; Shaywitz et al., 1999; Stella et al., 2010; Tressoldi et al., 2001; Tucci et al., 2013; Van der Leij et al., 2013), confirming that the critical sign of the disorder remains the reading speed.

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