Reading and spelling disabilities in children with and without a history of early language delay: a neuropsychological and linguistic study

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Running head: Neuropsychological and linguistic profiles in dyslexia

ABSTRACT

Language delay is a frequent antecedent of literacy problems, and both may be linked to phonological impairment. Studies on developmental dyslexia have led to contradictory results due to the heterogeneity of the pathological samples. The present study investigated whether Italian children with dyslexia showed selective phonological processing deficits or more widespread linguistic impairment and whether these deficits were associated with previous language delay.

We chose 46 children with specific reading deficits and divided them into two groups based on whether they had language delay (LD) or not (NoLD). LD and NoLD children showed similar, severe deficits in reading and spelling decoding, but only LD children showed a moderate impairment in reading comprehension. LD children were more impaired in phonological working memory and phonological fluency, as well as in semantic fluency, grammatical comprehension, and verbal IQ.

These findings indicate the presence of a moderate but widespread linguistic deficit (not limited to phonological processing) in a subset of dyslexic children with previous language delay that does not generalize to all children with reading difficulties.

Keywords: dyslexia, phonological processing, early language delay

INTRODUCTION

Although neuropsychological, neuroanatomical, and genetic investigations have been carried out for decades to determine the underlying causes of developmental dyslexia (DD), the problem is still not entirely understood. Indeed, according to Frith (2001) an exhaustive explanation of dyslexia requires the integration of three levels of description: behavioral, cognitive, and neurobiological.

At the behavioral level, the reading deficits shown by dyslexics are variable and differ in incidence, severity, and type. In the English language, the main symptom of dyslexia is reading inaccuracy; in languages with regular orthography, such as German and Italian (in which the relationships between letters and sounds are consistent), the most prominent difficulty of children with dyslexia is reduced reading fluency ('speed dyslexia', Wimmer, 1993). Nevertheless, although the performance of proficient readers is almost flawless in these languages, children with dyslexia do make some errors e.g., Judica, De Luca, Spinelli, & Zoccolotti, 2002).

At the cognitive level, a variety of factors have been proposed as possible causes of dyslexia. These, in turn, have given rise to different theoretical views (for a review see Ramus et al., 2003). The most well-known proposal is that phonological deficits are a common denominator of developmental dyslexia (for a review see Vellutino, Fletcher, Snowling, & Scanlon, 2004). In fact, there seems to be some agreement that phonological abilities are crucial for the acquisition of correspondences between letters and sounds (the foundation of reading in alphabetic systems) and that learning difficulties in written language are intimately linked to oral language difficulties, particularly phonological ones. However, opinions diverge as to the origin of the phonological impairment. Some authors have proposed that basic auditory perceptual deficits in temporal order perception are a common finding in children with dyslexia and correlate highly with their reading performance (Tallal, 1980). Replications of these original findings have not gone undisputed (for contrasting conclusions see reviews by Farmer & Klein, 1995; Tallal, Miller, Jenkins, & Merzenich, 1997; Vellutino et al., 2004). Other authors have proposed a "higher" view of the deficit, which includes phonological processing abilities: phonemic representation, storage, manipulation and awareness ('phonological core deficit' according to Stanovich & Siegel, 1994). Nevertheless, it is still unclear whether an isolated phonological deficit is sufficient to cause the reading impairment (Bishop & Snowling, 2004).

Snowling (2001) suggested that the variability seen in reading deficits is accounted for by differences in the severity of individual children's phonological impairment, which in turn may be modified by compensatory factors including not only other linguistic skills, such as semantic-syntactic abilities, but also extra-linguistic factors, such as visual memory, perceptual speed, or exposure time to print.

In the case of languages with regular orthography, it is unclear whether impaired reading speed is due to a deficit in phonological processing or a specific deficit in forming and/or accessing orthographic representations in memory. Wimmer and Mairynger (2002) found dissociations between dysfluent reading and unimpaired spelling and vice versa (i.e. poor spelling and unimpaired reading fluency) in fourth-grade German children. Only children with isolated spelling deficits (and unimpaired reading fluency) showed poor phonological short-term memory and poor phonological awareness when they started going to school. By contrast, children with a reading fluency deficit and unimpaired spelling did not exhibit any deficit in phonological short-term memory or phonological awareness, but performed deficiently on rapid naming tasks. According to the authors, these results suggest that the naming speed deficit might be independent from other phonological processing deficits and might mainly reflect a dysfunction in orthographic processing.

At the neurobiological level, investigations of the phonological hypothesis using fMRI and PET techniques have documented different patterns of activation in the left hemisphere language areas in dyslexics and normal controls during the performance of phonological tasks. Most of these studies reported reduced activity in the left temporo-parietal and temporo-occipital areas in dyslexic subjects compared with both age-matched (Bokde, Tagamets, Friedman, & Horwitz, 2001; Paulesu et al., 2001; Ruff, Marie, Celsis, Cardebat, & Démonet, 2003; Rumsey et al., 1997; Temple et al., 2001) and reading- matched (Brambati et al., 2006; Hoeft et al., 2006) controls, which was sometimes associated with hyper-activation in the left and right inferior frontal gyrus (Georgiewa et al., 2002; Hoeft et al., 2007; Pugh et al., 2000). This evidence represents a distinct developmental atypicality in the neural systems that support learning to read (Hoeft et al., 2007).

Other studies aimed at investigating visual processing abilities in dyslexics found abnormal activation patterns in the magnocellular visual subsystem (V5/MT) during the presentation of moving visual stimuli and in the exstrastriate cortex (BA 18, 19) during letter-matching tasks (Eden et al., 1996; Temple et al., 2001).

In summary, some findings support the hypothesis of a neurofunctional impairment of the language circuitries and others reveal abnormalities in the visual system. Results of neuroimaging studies are indicative of the complexity of the disorder, which, according to some authors, might be characterized by disruptions in the neural circuitries subserving both phonological and visual processes for reading

(Temple et al., 2001; López-Escribano, 2007). One reason for contradictory fMRI findings could be that different studies investigated the neural bases of selective deficits not necessarily shared by all dyslexics.

According to Frith (2001), both behavioral and cognitive characteristics of subjects should be taken into account and carefully specified to test any hypothesis on the pathophysiology of dyslexia. Cognitive and behavioral assessments should include an extensive evaluation of oral language abilities because patterns of reading impairment and of abnormal cerebral activation during phonological tasks might be the manifestation of a residual dysfunction of some language-related capacities.

Some support for the above hypothesis comes from follow-up data on early language delay and literacy acquisition of children with late onset of language and/or Specific Language Impairment (SLI) (Bishop & Adams, 1990; Catts 1993; Catts, Fey, Tombling, & Zang, 2002; Chilosi, Cipriani, Pfanner, Brizzolara, & Fapore, 2000; Rescorla, 2000; Rescorla, 2005; Stothard, Snowling, Bishop, & Chipchase, 1998), which shows that most of them present a relative weakness on tests of literacy and phonological processing. Nonetheless, as pointed out by Bishop and Clarkson (2003), 'few of the SLI children would be regarded as having clinically significant reading problems'. This observation contradicts a single-cause explanation of dyslexia and leaves open the question about the relationship between early language problems and later scholastic failure.

Within this conceptual framework, the general aim of the present research was to examine the role of linguistic deficits in young native speakers of a language with transparent orthography (Italian) who have been referred for suspected developmental reading deficits. The study was initiated as part of a more general investigation of the cognitive correlates of developmental dyslexia in children with and without previous language delay. In a parallel study, carried out on an independent sample, we contrasted the influence of phonological and rapid automatized naming (RAN) tests on dyslexia (Brizzolara et al., 2006a). According to the double deficit hypothesis (Wolf & Bowers, 1999), phonological and RAN tests indicate independent deficits that might add up in a proportion of cases and yield a more severe reading deficit. In our study (Brizzolara et al., 2006a), mild phonological deficits were confined to those dyslexics with a positive sign of language delay, whereas deficits in RAN were present independent of previous language delay.

In the present multiple-case series, we aimed to verify the nature of the linguistic deficits associated with dyslexia. For this purpose, a comprehensive evaluation of verbal abilities was carried out using tests that map phonological working memory, phonological and semantic fluency, receptive lexical and syntactic competence and expressive language. Operationally, we wished to investigate whether Italian children with developmental dyslexia show selective phonological or more widespread linguistic impairments and whether such deficits are present in all children with dyslexia or limited to those with previous language delay. Finally, we tested whether the severity of the reading (and spelling) impairment varied when previous language delay or residual linguistic weaknesses were present at the time of testing.

METHODS

Participants

The children included in the study were consecutively referred to the Centro Regionale per le Disabilità Linguistiche e Cognitive (Regional Centre for Linguistic and Cognitive Disabilities) of Bologna for suspected reading impairment.

They were included in the study if they met the following criteria:

- general intelligence level within normal limits (within one standard deviation on the PIQ or in the Full Scale IQ), as assessed by WISC-R (Wechsler, 1985; Italian Standardization, Orsini, 1993);
- impaired scores on standardized reading tests (word reading from the *Reading lists of words and non-words*, see below);
- regular school attendance;
- absence of adverse conditions in pre-, peri-, and post-natal clinical history;
- absence of neurological abnormalities on a standardized neurological examination.

A total of 46 (39 M, 7F) children fulfilled the above criteria over a period of 18 months. On average, the children were 10 years and four months old (SD = 17.1 months). The youngest children were third graders and the oldest were eighth graders.

Each child's clinical history was investigated by means of an assessment interview with their parents; this was carried out by a child neuropsychiatrist with special expertise in speech and language disorders (A.C.). The parents were also asked to fill out a questionnaire (Brizzolara et al., 2006a; Chilosi et al., 2003) on motor, cognitive, and language developmental milestones (see Appendix). In order to encourage the parents to recall basic language milestones, examples of typical children's utterances were provided. All questionnaires were checked by two independent raters (child neuropsychiatrists experienced in speech and language pathology) who did not participate in further testing of the children. A child was considered to have a history of language delay (LD) if the analysis of his or her questionnaire showed at least one of these signs: 1) no vocabulary burst before 24 months (19 children showed evidence of this); 2) late combinatory use of words, that is, after 30 months (N = 19); 3) persistence of grammatically incomplete sentences after four years of age (N = 15), and 4) persistence of phonological mispronunciations after four years of age (N = 18). Twenty-six children (23 M, 3 F) had at least one of these signs and were labeled as having a history of language delay (LD); they had a mean age of 10 years and three months (SD= 17.3 months). Most of these children (92%) showed two or more of the above signs, and about one third (35%) showed evidence of global language delay (all 4 signs present). No language delay (NoLD) was documented retrospectively in 20 children (14M, 6F); they had a mean age of 10 years and five months (SD=17.4 months). There were no significant differences in age ($t_{(118)} < 1$) or gender ($X^2 = .5$) between the LD and NoLD groups.

According to the questionnaires, 35% of the children in the LD group (but none in the NoLD group) had received language therapy during the pre-school years.

Each child also underwent an individual neuropsychiatric assessment to exclude the presence of abnormal neurological signs and socio-emotional disorders. A semi-structured interview allowed assessing the child's conversational skills at the discourse level. Language organization was evaluated using the following parameters: speech fluency, correctness of sentence construction, and presence/absence of phonological, lexical, and morphological errors. None of the dyslexic children showed overt signs of language impairment on this evaluation. However, an oral language weakness was present in some of these children when verbal functioning was more formally evaluated using standardized language tests (see Materials section below). Therefore, on the basis of these tests children were classified according to the presence or absence of an actual language weakness (respectively ALW, NoALW). Four areas were considered: 1) receptive lexicon, as assessed by the Peabody Picture Vocabulary Test (Dunn & Dunn, 1997); 2) receptive grammar (Test for the Reception of Grammar; Bishop, 1982); 3) expressive lexicon (Picture Naming Test; Brizzolara, 1989); and 4) verbal fluency (measured as the mean performance on the Phonemic and Semantic fluency tests). Children were classified as ALW if they scored 2 SDs or more below the norm on at least one index of language ability and/or 1 SD or more below the norm in at least two markers of language ability. On the basis of these criteria, 14 (54%) of the 26 LD children and one (5%) of the 20 NoLD children showed signs of actual language weakness. Verbal fluency, in which 7 children scored 2 SDs below the norm, was the most frequently impaired area. This was followed by expressive lexicon, in which five children were impaired. Only one child had a pathological performance on receptive lexicon, and none were impaired in receptive grammar. Four children showed a mild impairment in more than one linguistic area.

Materials

READING AND WRITING ABILITIES

The examination analyzed the following: 1) decoding skills in reading lists of words and non-words, 2) reading and comprehending meaningful passages, and 3) spelling proficiency in writing lists of words and non-words.

Reading lists of words and non-words.

Reading decoding ability was assessed by means of two sub-tests from the Battery for the Evaluation of Developmental Dyslexia and Dysgraphia (Sartori, Job, & Tressoldi, 1995). Two sub-tests of this battery were used to assess the children's ability to read aloud two lists, one comprised of 112 words and the other of 48 non-words. Number of errors and speed of reading (syllables/sec) were scored. Raw scores were converted to z scores according to standard reference data (Sartori et al., 1995). As stated above, performance on the Reading Word sub-test was one inclusion criterion, that is, only children performing at least 2 SDs below the mean in either speed or accuracy were included. This disjunctive criterion was used because it has been shown that dyslexics can flexibly adapt their speed-accuracy rate (Hendriks & Kolk, 1997); consequently, a selection based on either parameter (or both) might fail to detect selective cases of pathological performance. In this test, 29 children performed pathologically on both of the reading parameters, 9 performed pathologically only in terms of speed and 8 only in terms of accuracy.

Passage reading

Decoding and comprehension ability in reading texts was examined with a standardized reading achievement test (MT Reading Test, Cornoldi, Colpo, & Gruppo MT, 1995, 1998). The child read aloud a text passage with a 4-minute time limit; speed (syllable/sec) and accuracy (number of errors) were scored. Text reading comprehension was examined with a standard reading achievement test (MT Reading test). A meaningful passage was presented without a time limit. The participant had to read it silently and respond to multiple-choice questions. Stimulus materials, number of questions (10 or 15) and related reference norms varied with school level. Raw scores were converted to z scores according to standard reference data (Cornoldi et al., 1995, 1998).

Spelling

Writing skills were assessed by means of two sub-tests from the Battery for the Evaluation of Developmental Dyslexia and Dysgraphia (Sartori et al., 1995): Writing Words and Writing Non-words to dictation. In the first sub-test, 48 words were read to the child who had to write them down. In the second, 24 non-words were dictated. The number of words (or non-words) incorrectly spelled was calculated. Raw scores were converted to z scores according to normative values (Sartori et al., 1995). Measures on these sub-tests were collected for a sub-set of 34 children (19 LD and 15 NoLD).

VERBAL ABILITIES

Evaluation of verbal abilities was carried out using tests of 1) phonological working memory, 2) receptive and 3) expressive language, and 4) verbal intelligence.

Working memory

The Phonological Working Memory Test was used (Brizzolara, Casalini, Sbrana, Chilosi, & Cipriani, 1999). This test consists of the acoustic presentation of lists of words. Six lists, which varied for number of words (from 2 to 6), were used. Four lists varied for word length (two-syllable and four-syllable words) and word frequency (high and low). Two lists of phonologically similar and phonologically dissimilar two-syllable words were also presented. For each list, memory span was calculated as the number of the longest sequences correctly repeated at least twice out of five presentations. The raw scores were converted to z scores according to standard reference data (Brizzolara et al., 1999).

Receptive language

Lexical competence was measured by means of the Peabody Picture Vocabulary Test (PPVT; Dunn & Dunn, 1997). This test is an un-timed, individually administered test that features the oral presentation of 5 training items followed by 175 test items arranged in order of increasing difficulty. Each item has four simple, black-and-white illustrations arranged in a multiple-choice format. The subject's task is to select the picture that illustrates best the meaning of a stimulus word presented orally by the examiner. PPVT has been standardized on Italian children (Stella, Pizzoli, & Tressoldi, 2000).

Syntactic comprehension was assessed by the Test for the Reception of Grammar (TROG; Bishop, 1982; Italian adaptation: Cedron, Lonciari, & Sartori, www.neuropsy.it/test/trog). TROG uses a multiple-choice format. The child is shown a page with four pictured choices and has to select the picture that matches a spoken sentence. Although there are 80 items, testing is discontinued after a certain number of errors have been made; therefore, all items are not always given. TROG is intended to be a relatively pure measure of understanding of grammatical contrasts rather than a test of comprehension in everyday situations. Measures on this test were available for a sub-set of 33 children (20 LD and 13 NoLD).

Expressive language

Phonemic fluency was tested using a task in which the child was requested to produce as many words as possible beginning with a given letter sound within one minute. Three trials (with beginning letter sounds /f/,/a/, and s/) were given. The score (total numbers of words correctly produced) was converted to z values with reference to a sample of 139 children between 8 and 11 years of age (Pignatti, 1999).

A semantic fluency task was also administered. The child was requested to produce as many words as possible belonging to four categories: colors, animals, fruits and towns. The score (total numbers of words correctly produced) was converted to z values with reference to a sample of 139 children between 8 and 11 years of age (Pignatti, 1999).

To evaluate lexical production, a standardized Italian test was administered (Picture Naming Test; Brizzolara, 1989). The test consists of the presentation of 104 pictures corresponding to high (52) and low (52) frequency words. In each display, the child must name each of the four simple, black-and-white pictures presented. Separate scores for high- and low-frequency words were obtained and transformed to z values with reference to a sample of 154 children between 8 and 11 years of age (Brizzolara, 1989).

Verbal IQ

Verbal intelligence was tested by means of the Verbal Scale of the WISC-R (Wechsler, 1985; Italian adaptation: Orsini, 1993).

NON VERBAL ABILITIES

Visual motor integration was assessed by means of the Beery Developmental Test of Visual-Motor Integration (VMI; Beery & Buktenika; Italian adaptation, 2000). VMI is a copying test that consists of 27 geometric shapes of increasing complexity. Raw scores were transformed into standard scores according to standardized Italian data.

Visuo-spatial working memory was evaluated by means of the Corsi Block-tapping Test (Milner, 1971). The test is administered on a 25x30 cm wooden board on which nine cubes are randomly located. The Examiner touches sequences of cubes of increasing length, and the subject is required to reproduce them. The score is the longest sequence correctly reproduced in at least 2 out of 3 trials. Raw scores were converted to z scores according to normative values (Orsini, Grossi, Papagno, & Vallar, 1987).

Performance IQ

Non-verbal intelligence was tested by means of the Performance Scale of the WISC-R (Wechsler, 1985; Italian adaptation: Orsini, 1993).

Data analysis

First, we evaluated the level of performance of LD and NoLD children on the various tests with respect to standard normative values. To this aim, different types of scoring were used depending on the reference norms (z scores, weighted standard scores). As for the verbal and visuo-spatial tests, we also calculated the proportion of cases showing a clearly pathological performance (i.e., at least 2 SDs below the norms).

Second, we performed statistical tests to compare LD and NoLD groups. For tests with a single dependent measure, the two groups were compared using the Student t test for independent samples. For tests with multiple dependent measures, ANOVAs including one or two repeated measure factors were carried out.

Finally, we examined the influence of an actual language weakness on written language measures. Statistical tests used for these comparisons were the same employed for comparing LD and NoLD children.

RESULTS

Reading and spelling

Performances on the reading and spelling tests are reported in Table 1.

Reading lists of words and non-words

Inspection of Table 1A indicates a marked reading deficit, in keeping with the selection criteria. Both LD and NoLD children had impaired accuracy and speed. As expected, the percentage of errors was greater for non-words than words. As compared to normative data (z scores), however, the reading deficit appeared more pronounced for the lexical items.

A three-way ANOVA with group (LD, NoLD) as unrepeated factor and type of stimulus (words, non-words) and reading parameter (speed, accuracy) as repeated factors was performed on the z scores. Neither the main effect of the group factor ($F (1, 44) = 1.55$, p = n.s.) nor the interactions involving this factor were significant. The effect of the type of stimulus factor was significant ($F (1, 44) = 10.45$, $p < .01$), that is, the deficit was greater for words ($z = -3.93$) than non-words ($z = -2.72$). The effect of the reading parameter was significant ($F (1, 44) = 9.49$, $p < .01$), indicating a more pronounced deficit for accuracy ($z = -4.35$) than speed ($z = -2.30$). Finally, the type of stimulus by reading parameter interaction was significant ($F (1, 44) = 4.71$, $p <. 05$), that is, for accuracy the deficit was larger for words than non-words, and no difference was present for reading speed.

******** Insert Table 1 ********

Text reading

Reading speed and accuracy were generally impaired also for text reading (see Table 1B).

A two-way ANOVA with group (LD, NoLD) as unrepeated factor and reading parameter (speed, accuracy) as repeated factor was carried out on the z scores. The main effect of the group factor (F (1, 43) = 1.40, p = n.s.) was not significant. The effect of the reading parameter was significant (F (1, 43) = 7.4, p < .01), that is, performance was worse for speed (z =-2,75) than for accuracy (z=-2,03). The group by reading parameter interaction tended toward significance (F (1, 43) = 3.63, p = .06) in that the difference between accuracy and speed was more evident in the NoLD children. These children were more impaired in speed than accuracy, whereas the LD group was equally impaired in both parameters.

Reading comprehension

When their scores were compared to normative values, both LD and NoLD children had only mildly impaired reading comprehension (see Table 1B). However, LD children tended to score lower (z = -0.95) than NoLD children (z = -0.34; t (43) = 1.84, p = .07) and with greater variability.

Spelling

Both LD and NoLD groups were severely impaired in spelling (see Table 1C). In absolute terms, they made more errors in writing non-words than words, as expected. However, when this deficit was expressed in relation to the performance of normative data, the deficit was considerably greater for words than non-words; this trend was apparent in both groups of children.

A two-way ANOVA with group (LD, NoLD) as unrepeated factor and type of stimulus (words, non-words) as repeated factor was carried out. The main effect of the group factor was not significant (F (1, 32) < 1). The effect of the type of stimulus factor was significant (F (1, 44) = 43.96, p < .001), indicating higher performances for non-words (z = -1.96) than words (z = -7.25). The group by type of stimulus interaction was not significant (F < 1).

Summary of findings

As expected on the basis of the inclusion criteria, both dyslexics with and without language delay showed marked deficits in reading lists of words and non-words (notably, the two groups did not differ on these two types of stimuli). The reading deficit (and the absence of group differences) was confirmed in a test examining functional reading of a meaningful passage. Furthermore, children showed a marked deficit in spelling; this finding is in keeping with a close association between reading and writing deficits.

The two groups were only mildly affected in reading comprehension. In this case, however, a moderate group difference was apparent. The LD children tended to be relatively more impaired in reading comprehension than the NoLD children.

Verbal tests

Performances on verbal tests are reported in Table 2. In general, mean performances indicate no deficit or mild cognitive impairment. Note that the LD group performed worse on all measures, particularly on a few specific tests.

Phonological working-memory

As a group, LD children were mildly affected in most stimuli conditions of the Phonological Working-Memory Test (see Table 2A); note that performances in the Phonologically similar bi-syllable condition did not appear selectively affected as compared to all other conditions. The NoLd children performed well within the normal limits in all conditions.

A two-way ANOVA with group (LD, NoLD) as unrepeated factor and type of stimulus (high-frequency bi-syllables, low-frequency bi-syllables, phonologically similar bi-syllables, phonologically dissimilar bi-syllables, high-frequency four-syllables, low-frequency four-syllables) as repeated factor was carried out on the z scores. The main effect of the group factor was significant ($F (1, 44) = 8.30$, $p < .01$), indicating a generally lower performance for LD ($z = -0.74$) than NoLD ($z = 0.08$) children. The main effect of the type of stimulus factor was significant ($F (5, 220) = 5.39$, $p < .001$): Bonferroni post-hoc comparisons showed lower performances in the low-frequency bi-syllables ($z = -0.62$) and high-frequency four-syllables ($z = -0.83$) conditions with respect to the low-frequency four-syllables ($z = 0.05$), and in the high-frequency four-syllables with respect to the phonologically similar bi-syllables ($z = 0.00$) conditions. The group by type of stimulus interaction was not significant ($F < 1$).

Analysis of individual cases indicated that no child in either group scored below 2 SDs from the norms in any conditions. However, three children in the NoLD group scored below 2 SDs in at least one out of six conditions and one out of two conditions; in the LD group, 16 children had at least one deficient performance (one of these children in two conditions and four in three conditions).

******** Insert Table 2 ********

Receptive vocabulary

Both groups of children performed well within the normal limits on the Peabody Picture Vocabulary Test (see Table 2B).

There was no difference in the LD and NoLD children's performance on the PPVT ($t (44) = 1.69$, n.s.). One child in the LD group (and none in the NoLD group) performed deficiently on this test.

Syntactic comprehension

Overall, the group performances of both LD and NoLD children were not impaired.

LD children performed significantly lower ($z = 0.17$) than NoLD children ($z = 0.89$); $t = 2.03$, $p = .05$). No child in either group performed deficiently on this test.

Verbal Fluency

As a group, LD children were mildly affected in phonemic fluency and more markedly affected in semantic fluency. NoLd children performed well within the normal limits on both tests.

A two-way ANOVA with group (LD, NoLD) as unrepeated factor and task (phonemic, semantic fluency) as repeated factor was carried out on the z scores. The main effect of the group factor was significant ($F (1, 44) = 16.78$, $p < .001$), indicating a lower performance for LD ($z = -1.30$) than NoLD children ($z = -0.10$). The main effect of the task factor was significant ($F (1, 44) = 9.19$, $p < .01$), indicating lower performance on the semantic ($z = -1.05$) than the phonemic fluency ($z = -0.35$) test. The group by task interaction was significant ($F (1, 44) = 4.96$, $p < .05$). LD children performed worse than NoLD children on both tasks; however, the difference was more marked in the semantic fluency task.

Analysis of individual cases indicated that three children in the LD group scored below 2 SDs from the norms on the phonemic fluency test and 14 children on the semantic fluency test. In the NoLD group, these figures were 0 and 2, respectively.

Expressive vocabulary

Performance on the Picture Naming Test was only marginally affected in both groups of children (see table 2).

A two-way ANOVA with group (LD, NoLD) as unrepeated factor and frequency (high, low) as repeated factor was carried out on the z scores. The main effect of the group factor was not significant ($F(1, 44) = 1.29$, n.s.). The main effect of the frequency factor was significant ($F(1, 44) = 5.12$, $p < .05$), indicating lower performance for low frequency ($z = -0.60$) than high frequency ($z = -0.32$) words. The group by task interaction was not significant ($F(1, 44) < 1$).

Analysis of individual cases indicated that two children in the LD group scored more than 2 SDs below the norms in one condition and two in both conditions. In the NoLD group, none of the children showed a deficient performance.

Verbal IQ

Partly as an effect of the selection criteria, mean verbal IQs on the WISC-R scale were well within normal limits in both groups of children. However, LD (96.8) children scored significantly lower than NoLD children (107.8), $t(43) = 2.76$, $p < .01$).

Summary of findings

Performances of NoLD children were generally not affected in any verbal domains, with a mean performance close to the expected normative values.

Analysis of LD children indicated a mild to moderate deficit with sparing of expressive and receptive vocabulary abilities. Group differences were reliable in terms of working memory, phonemic fluency, syntactic comprehension and verbal IQ. The largest difference was detected for the ability to retrieve items rapidly on a semantic probe. Analysis of individual cases confirmed that truly pathological performances were infrequent on most tests (with the exception of the semantic fluency test), but were occasionally present in the LD children.

Non-verbal abilities

Performances on non-verbal tests are reported in Table 3. Note that mean performances of both groups fall well within normal limits on all tests.

Visual-motor integration

No group difference was present in the VMI test ($t(44) = -.92$, n.s.). Only one child in the NoLD group performed deficiently on this test.

Non verbal short-term memory

LD and NoLD children did not differ on the Corsi Block Tapping test (t (44) = -1.29, n.s.). No child in either group performed defectively on this test.

Performance and Full-scale IQ

No between-group difference was present for performance IQ (t < 1).

LD children scored significantly lower (99.1) than NoLD (105.4) children on the Full Scale IQ (t (44) = 2.03, p < .05).

******** Insert Table 3 ********

Summary of findings

Both LD and NoLD children showed largely spared visuo-motor abilities (i.e. visuo-motor integration, non verbal short-term memory, performance IQ). The small but reliable difference in full IQ apparently depends on performance on the Verbal Sub-scale of the WISC-R.

Influence of actual language weakness on written language measures

Performances of ALW and NoALW children on the reading and spelling tests are reported in Table 4. Inspection of the table shows that both groups of children were severely and similarly impaired in reading decoding and spelling. As for reading comprehension, only the ALW children performed pathologically.

A three-way ANOVA with group (ALW, NoALW) as unrepeated factor and type of stimulus (words, non-words) and reading parameter (speed, accuracy) as repeated factors was performed on the z scores of the *Reading lists of words and non-words* test. Neither the main effect of the group factor (F (1, 44) = 0.001, p = n.s.) nor the interactions involving this factor were significant. All other effects and interactions were very similar to those of the same analysis with language delay as a grouping factor.

In the text reading test, an ANOVA with group (ALW, NoALW) as unrepeated factor and reading parameter (speed, accuracy) as repeated factor showed neither a main effect of the group factor (F (1, 43) = 1.04, p = n.s.) nor an interaction between this factor and the reading parameter (F (1, 43) = 2.18, p = n.s.). The type of reading parameter effect fell short of significance (F = 2.45, p = .12, n.s.).

As for text comprehension, ALW children performed worse (z = -1.51) than NoALW children (z = 0.36; t (43) = 3.54, p < .005).

Finally, in the spelling test an ANOVA with group (ALW, NoALW) as unrepeated factor and type of stimulus (words, non-words) as repeated factor indicated no main effect of the group factor (F (1, 32) = 0.24, p = n.s.) and no group by type of stimulus interaction (F (1, 32) = 0, 25, p = n.s.). The type of stimulus effect was similar to that in the analysis with reading delay as a grouping factor.

Summary of findings

Oral language weakness at the time of written language assessment did not contribute to the severity of difficulty in reading decoding and spelling. ALW children did not perform worse than NoALW children on measures of reading and spelling accuracy or on measures of reading speed.

Instead, actual language weakness had a significant impact on reading comprehension. While NoALW children performed well within the normal limits on a test of reading comprehension, ALW children performed pathologically.

DISCUSSION

The aim of the present study was to determine whether dyslexia is a homogeneous condition that always involves a phonological processing deficit or whether, in a language with a regular orthography, it is associated with a broader linguistic impairment. The study was carried out by comparing the neuropsychological profiles of Italian dyslexics with (LD) and without (NoLD) early language delay. We expected that only the former condition would be associated with a mild, residual, linguistic deficit extending beyond the phonological domain. Although in the present study we extended the linguistic investigation to other components of the language system, in our parallel study (Brizzolara et al., 2006a) we took into account only the phonological dimension.

Evaluation of reading (and spelling) ability confirmed marked decoding deficits in LD and NoLD children. Both groups were impaired in reading lists of words and non-words, as well as in reading a meaningful passage. Furthermore, they showed a marked deficit in writing. This finding is in keeping with a close association between reading and spelling deficits and confirms previous evidence of marked spelling deficits in Italian children with dyslexia (Angelelli, Judica, Spinelli, Zoccolotti, &

Luzzatti, 2004). Notably, on no test did the two groups differ for severity of their reading and spelling deficits. This lack of difference could have been due to the restrictive inclusion criterion, that is, of a performance at least 2 standard deviations below the mean. Nevertheless, as there was considerable variation within each group a difference in severity would have been detected. Note also that in our parallel study on the late effects of early language delay on literacy (Brizzolara et al., 2006a), we failed to observe any difference in severity of the reading deficit in children with and without language delay. Moreover, although the children did not show any clear signs of a language deficit at the clinical interview, the formal language assessment performed at the time of testing revealed the presence of actual language weaknesses in different areas of linguistic functioning. These deficits characterized about half of the children who had a history of previous language delay and were only sporadically present in children who had no previous language delay. Interestingly, the presence of oral language weakness at the time of assessment did not contribute significantly to the presence and severity of dyslexia. Overall, both the analyses based on the language delay classification and those based on the actual language weaknesses provide evidence that difficulty in the transcoding components of written language are not simply a consequence of oral language weakness and viceversa.

The reading deficit was apparent for both speed and accuracy. It has been observed that reading speed is the most prominent feature of dyslexic children in orthographically regular languages and that their reading is comparatively correct (Wimmer, 1993). Nevertheless, although their absolute number of errors is considerably lower than that shown by dyslexics in languages with opaque orthographies, they usually show a deficit in accuracy when their performance is compared with the nearly flawless performance of proficient readers (e.g., Judica et al., 2002). The present findings generally confirm this pattern. Some inconsistency was apparent between tests, with reading accuracy more affected for lists and reading speed more affected for texts. It is difficult to make a definitive interpretation of this pattern of results. The former finding may have been due to the presence of some range restriction in the norms, at least for words, because skilled Italian readers make few errors by the end of elementary school (Sartori et al., 1995). This range restriction may have inflated the estimate of the deficit in accuracy as compared with that in speed. Finally, it should be noted that there was a tendency in the data for the LD children to be more impaired in reading accuracy than speed and viceversa for the NoLD children. However, this effect emerged as a statistical trend for text passages and was not significant for lists of words and non-words. One interpretation could be that LD children use semantic compensatory strategies less efficiently than NoLD children in text reading because of their previous language delay. Nevertheless, although no firm conclusions can be reached from these data, the possibility that children without evidence of previous language delay have more selective speed deficits seems worthy of further investigation.

It has been proposed that analyzing reading performance on lexical versus non-lexical stimuli might be useful for interpreting the reading deficit (Rack, Snowling, & Olson, 1992). Several studies of English-speaking children have shown that those with dyslexia are particularly affected in reading non-words. This is in keeping with the relative fragility of the grapheme-to-phoneme conversion routine (Rack et al., 1992; Ijzendoorn & Bus, 1994; Herrman, Matyas, & Pratt, 2006). In the present data, both groups of children scored lower on non-words than words in the case of raw data. However, when expressed as standardized scores, no selective deficit for reading non-words was present in either group. In fact, the opposite trend was found, that is, the deficit was greater for words. These data confirm previous evidence in Italian dyslexics (e.g., Judica et al., 2002). It has been proposed that Italian dyslexics predominantly show a surface pattern with relative sparing of their ability to read by the grapheme-to-phoneme conversion routine (Zoccolotti et al., 1999). Importantly, the lexical-nonlexical dimension did not vary in the presence of early language delay. In other words, both LD and NoLD children failed to show any selective deficit for reading non-words. Parallel findings were obtained for writing skills. Irrespective of the presence of previous language delay, children were markedly impaired in writing words and less impaired in writing non-words, a pattern consistent with previous evidence in Italian children (Angelelli et al., 2004). According to these authors, the pattern expresses a predominantly lexical deficit (surface dysgraphia) and relatively spared functioning of the sub-lexical routine. Accordingly, the deficit is more marked in the case of stimuli with lexical value.

Reading comprehension was only mildly affected in the two groups. This finding is customary in Italian dyslexics. Provided that enough time is allowed, even children with impaired decoding skills can understand the meaning of a text passage reasonably well (e.g., Judica et al., 2002). In this case, however, a moderate group difference was present. The LD children tended to be relatively more impaired in reading comprehension than the NoLD children. Similar results were obtained in our twin study (Brizzolara et al., 2006a). The new finding of the present study is that an actual language weakness showed an even stronger relationship to a problem in reading comprehension. The presence of residual language weakness, as determined by formal testing, was associated with significant difficulty in text comprehension; on the contrary, those children who did not present an actual language weakness did not demonstrate reading comprehension deficits. It has been proposed that the link between oral linguistic skills and reading is particularly clear in the case of measures of reading comprehension (Bishop & Snowling, 2004). In fact, this latter ability requires the integration of different linguistic components (lexical-semantic, morpho-syntactic), which can be relatively weak in children with language delay.

The neuropsychological profiles of the two groups differed significantly in several language domains. Performance of NoLD children was generally not affected. In fact, their mean scores were close to the expected normative values for all language tests. In contrast, when LD children were analyzed more variable results emerged. In fact, mean group performance varied from normal to moderate impairment. A mild deficit in phonological working memory and phonological fluency, as well as a more marked deficit in the retrieval of items from a semantic probe, was evident in the LD group. However, it must be kept in mind that with regard to individual differences only a few children showed a truly pathological performance and only in a few conditions. When compared with NoLD children, LD children showed differences across different linguistic domains, not just phonological processing. They were less efficient in phonological working memory and phonological fluency as well as in semantic fluency and grammatical comprehension. It should be noted that the Phonological Working Memory Test included conditions that contrasted phonologically similar words with phonologically dissimilar words; notably, the difference between the two groups was not more marked in the condition with a greater load on phonological contrast. Again, this finding does not point to a selective phonological impairment. Finally, the generality of the linguistic differences between the groups was also captured by a general measure of linguistic functioning (verbal IQ). At any rate, it should be noted that in verbal IQ (as well as in syntactic comprehension) LD children as a group performed within normal limits, that is, the relative fragility of their linguistic functioning emerged only when they were compared with a group of NoLD children. Furthermore, LD children were largely spared in receptive and expressive vocabulary in un-timed conditions, a finding that prevents a direct lexical interpretation of their reading deficit. Overall, the profile of LD children indicates a moderate but widespread linguistic weakness not limited to phonological processing. It is therefore doubtful that a single cause, in particular a phonological deficit, is responsible for all clinical manifestations of dyslexia. This conceptual framework could explain why some of the children who recovered an early language delay developed a reading problem and others did not (Brizzolara et al., 2007; Brizzolara et al., 2006b; Catts 1993; Catts et al., 2002; Chilosi et al. 2000; Goulandris, Snowiling, & Walker, 2000; Schuele, 2004).

The evidence that phonological processing deficits appear to be part of a broader, mild language dysfunction in dyslexics with a history of language delay (LD) is in line with Stothard et al.'s (1998) and Bishop and Clarkson's (2003) follow-up data showing that only children with several impaired components of language processing in the pre-school years have long-term literacy problems. As Bishop and Snowling (2004) clearly state, it is important to search for different linguistic markers in several dimensions of impairment rather than to rely on a single dimension, such as phonological deficits. In a recent longitudinal investigation of children with a family risk of dyslexia, Snowling (2008) found that a phonological deficit in the pre-school years was a common feature of children with and without literacy impairment at 8 years. However, only the at-risk children who went on to have literacy problems showed a rather widespread pattern of language delay in the pre-school years (slow development of receptive and expressive language skills and vocabulary knowledge).

Overall, the question remains open as to whether the relationship between language delay and reading disability should be seen in terms of co-morbidity or as a causal link between oral and written language deficits. In other words, in LD children it is not clear whether a common core deficit leads to both oral and written language problems or whether the residual language deficits co-occur with impairment of some selective processes involved in learning to read. Currently, there is renewed interest in developing formal models of co-morbidity to interpret the frequent co-occurrence of learning disabilities (Pennington, 2006). This approach might be particularly useful for interpreting the frequency of previous language delay in the personal history of dyslexic children.

Both LD and NoLD children were largely spared in the non-verbal abilities investigated in the present study (visual-motor integration, non verbal short-term memory, performance IQ).

From a neurobiological point of view, it can be speculated that the different behavioral phenotypes identified in our research have different neurobiological substrates, as indicated by recent neuroimaging studies on children with dyslexia. The presence of a linguistic deficit at the cognitive level could be associated with morphological and/or functional alterations of the inferior frontal gyrus and temporo-parietal areas of the left-hemisphere, as suggested by some recent neuroimaging studies (Leonard et al., 2001; Paulesu et al., 2001; Pecini et al., submitted; Ruff, Cardebat, Marie, & Démonet, 2002). Conversely, the reading deficit (in the absence of a linguistic impairment) could be the manifestation of a dysfunction of the neural networks (parieto-temporal-occipital) involved in accessing and retrieving letters and orthographic representations at a prelexical level (Chase 1996; Eden et al., 1996; Jobard, Crivello, & Tzourio-Mazoyer, 2003; Livingstone, Rosen, Drislane, &

Galaburda, 1991) or of the circuitries subserving the timing mechanisms that regulate fast and automatic access to the written code (fronto-cerebellar; see Eckert et al., 2003). In this perspective, the correct identification of dyslexics at the behavioral and cognitive level appears to be a necessary prerequisite for orienting neurobiological research and cognitive rehabilitation. Therefore, it can be hypothesized that distinct or partially overlapping areas of dysfunction in the brain might underlie different cognitive deficits (whether single or multiple) of dyslexia.

A final point concerns the implications of the present findings for neuropsychological practice. From a developmental point of view, our data suggest the importance of carefully monitoring children who show language delay in the preschool years in the first phases of literacy acquisition to detect possible reading and spelling problems and plan for early intervention. However, it should be expected that in many cases these precautions will not be taken. In fact, we have tested children who were originally referred for suspected reading problems. It is likely that in some children previous language delay was not severe enough to trigger a diagnostic check. Consequently, only retrospective information on language difficulty could be obtained. Admittedly, this approach has important limitations, particularly for obtaining detailed information on the nature of the previously encountered linguistic problems. Thus, it would be important to corroborate the present findings in a longitudinal prospective study. It could be that the absence of previous formal linguistic information at the time of referral for suspected learning disabilities is relatively common in diagnostic practice. In this perspective, the present findings underscore the importance of acquiring information through structured interviews on the milestones of language acquisition.

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Table 1

Reading and spelling performances of LD and NoLD children.

			LD children		NoLD chidren	
Parameter	Stimulus	Measure	Mean	SD	Mean	SD
A) Lists of words and non-words						
Speed	Word	Z score	- 2,45	0,75	- 2,58	0,63
	Non word	Z score	- 1,95	0,86	- 2,19	0,78
Accuracy	Word	Z score	- 6,59	7,29	- 4,11	5,39
		% errors	18	10	13	16
	Non word	Z score	- 3,97	3,47	-2.75	1.93
		% errors	36	16	31	14
B) MT Reading test						
Speed	Text	Z score	-2.71	.73	-2.83	.85
Accuracy	Text	Z score	-2.49	.37	-1.58	.43
		% errors	10.5	7.3	5.8	3.3
Comprehension	Text	Z score	-0.95	1.19	-0.34	0.92
		% correct	48	24	64	22
C) Spelling test						
Accuracy	Word	Z score	-7.33	4.84	-7.16	5.76
		% errors	26	20	22	15
Accuracy	Non-word	Z score	-2.08	1.99	-1.84	1.61
		% errors	32	21	29	14

Table 2

Performances of LD and NoLD children on verbal tests. Values indicate mean (and SD) z scores.

	LD		NoLD	
	M	SD	M	SD
A) Phonological Working Memory test				
High-frequency bi-syllables	-1,21	1,32	-0,03	1,07
Low-frequency bi-syllables	-0,84	1,03	0,20	1,27
Phonologically similar bi-syllables	-0,25	1,13	0,25	1,23
Phonologically dissimilar bi-syllables	-0,58	0,73	0,08	1,19
High-frequency four-syllables	-1,19	1,31	-0,47	1,34
Low-frequency four-syllables	-0,36	1,04	0,47	0,84
B) Receptive language				
Peabody Picture Vocabulary test	0,20	0,80	0,60	0,80
TROG	0,17	1,05	0,89	0,87
C) Expressive language				
Phonemic fluency	-0,70	1,08	-0,01	0,88
Semantic fluency	-1,90	1,62	-0,19	1,23
Picture Naming Test: high frequency words	-0,47	1,11	-0,12	0,64
Picture Naming Test: low frequency words a	-0,73	1,35	-0,51	0,83
WISC-R Verbal IQ (standard score)	96.8	13.9	107.8	12.0

Table 3

Performances of LD and NoLD children on non-verbal tests. Performances on the WISC Full Scale are also presented.

	LD		NoLD	
	M	DS	M	DS
VMI (z scores)	-.40	.87	-.65	.93
Corsi test (z score)	.71	1.45	.19	1.25
Performance IQ (standard score)	101.7	8.4	102.4	12.5
Full scale IQ (standard score)	99.1	10.6	105.4	10.1

Table 4

Reading and spelling performances of ALW and NoALW children.

			ALW children		NoALW chidren	
Parameter	Stimulus	Measure	Mean	SD	Mean	SD
A) Lists of words and non-words						
Speed	Word	Z score	-2.44	0.95	-2.54	.59
	Non word	Z score	-1.77	1.10	-2.17	.68
Accuracy	Word	Z score	-5.99	4.28	-5.32	7.34
		% errors	18	12	15	14
	Non word	Z score	-3.38	1.96	-3.47	3.27
		% errors	34	15	34	16
B) MT Reading test						
Speed	Text	Z score	-2.71	0.82	-2.76	0.78
Accuracy	Text	Z score	-2,69	1.92	-1.87	1.89
		% errors	10	6	8	6
Comprehension	Text	Z score	-1.51	1.30	0.36	0.84
		% correct	35	24	63	20
C) Spelling test						
Accuracy	Word	Z score	-7.05	4.55	-7.32	5.45
		% errors	23	19	24	17
Accuracy	Non-word	Z score	-2.49	2.40	-1.82	1.62
		% errors	36	27	29	14

Appendix

QUESTIONNAIRE ON MOTOR, COGNITIVE, AND LANGUAGE DEVELOPMENTAL MILESTONES (FOR PARENTS)

Child's last name, first name …………… gender M ☐ F ☐
Date of Birth …………… Place of Birth ……………
Address …………… telephone number ……………
Date of observation ……………

GENERAL INFORMATION
Nursery ☐ Kindergarten ☐ Primary School ☐ class……….…. Middle school (10-13 years) ☐ class………
Secondary School (13-18 years) ☐ class …………… Other ☐ ………
Does your child have a remedial teacher? ☐ NO ☐ SI'
Who sent you to this service? ……………
Why was your child referred to us? ……………
Has your child been followed up by other services? ☐ NO ☐ YES. If so, which ones? …………
Has your child had speech therapy? ☐ NO ☐ YES. If so, please indicate from what age, for how long and how frequently (weekly, monthly) ……………

FAMILY HISTORY
Did any other family member have language problems? NO ☐ YES ☐. If so, who? ……………
Did any other family member have difficulty in learning to read and write? NO ☐ YES ☐.
If so, who? ……………
Did any family member have developmental delays or behavioral disorders? NO ☐ YES ☐.
If so, who and what type of disorder? ……………

PERSONAL HISTORY
Pregnancy problems: NO ☐ YES ☐. If so, what type? ……………
Perinatal complications: NO ☐ YES ☐. If so, what kind? ……………
Apgar score: ……………
Weight at birth: ……………
Was cyanosis present at birth? NO ☐ YES ☐. If so, please explain ……………
Was jaundice present at birth? NO ☐ YES ☐ ……………
If so, was it treated with a lamp? NO ☐ YES ☐
With barbiturates? NO ☐ YES ☐
Duration of hospitalization: ……………
Exams and treatments: ……………
Did your child suckle well? NO ☐ YES ☐ ……………
Was your child breastfed? NO ☐ YES ☐ ……………
Does your child have a regular sleep/wake rhythm? NO ☐ YES ☐ ……………
Did your child have problems with weaning, chewing, and hypersalivation? NO ☐ YES ☐
If so, please specify ……………

MOTOR DEVELOPMENT
At what age did your child sit without support? ……………
At what age did your child walk without support? ……………
At what age was your child able to ride a bicycle? ……………
Dominance: right ☐ left ☐ ambidextrous ☐ ……………

LANGUAGE DEVELOPMENT
At what age did your child say his/her first words? ……………
At what age did your child produce his/her first word combinations (that is, put two or more words together), for example, "mommy shoes", "cereal hot", "Daddy gone")? ……………
At what age did your child start saying simple grammatically correct sentences (for example, "I wash my doll").
At what age did your child start saying complex grammatically correct sentences (for example, "the baby's crying because he fell down") …………………………
At what age did your child start listening to fairy tales? ……………
And watching cartoons? ……………
Did your child have difficulty pronouncing some sounds NO ☐ YES ☐
If so, until what age? ……………
Do you think your child had some language problems when he/she went to primary school? NO ☐ YES ☐. If so, which problems? ……………

SOCIAL AND EMOTIONAL DEVELOPMENT
Did your child have difficulties while entering nursery school? NO ☐ YES ☐.
Did your child have difficulties while entering kindergarten? NO ☐ YES ☐.
Did your child have persistent difficulty separating from you or from significant others? NO ☐ YES ☐. If so, please specify ……………
Did your child have difficulty socializing or participating in activities with the other children? NO ☐ YES ☐. If so, please specify ……………
When was your child completely toilet trained?
Daytime …………… nighttime ……………
Does your child have problems sleeping? NO ☐ YES ☐. If so, please specify ……………
Does your child sleep alone in his/her bedroom? NO ☐ YES ☐ ……………
Has your child ever been nervous or intolerant of rules and frustrations? NO ☐ YES ☐.
If so, please specify ……………
Is your child very active or has he/she ever had difficulty concentrating on activities? NO ☐ YES ☐. If so, please specify ……………

HISTORY OF ILLNESSES
Did your child suffer from earaches and/or otitis? NO ☐ YES ☐. If so, how often? ……………
Has your child ever been examined by an ear, nose and throat specialist? NO ☐ YES ☐. If so, what was the diagnosis? ……………
Has your child ever had a hearing test? NO ☐ YES ☐. If so, what were the results? ……………
Has your child ever had febrile convulsions or epileptic seizures? NO ☐ YES ☐.
If so, please specify current medication: ……………
Has your child ever suffered from a head injury? NO ☐ YES ☐. If so, when and what were the consequences? ……………

Has your child had any particular health problems? NO ☐ YES ☐. If so, specify ……………
Has your child ever had his/her eyes examined? NO ☐ YES ☐. If so, when? ……………
Does your child have eyesight problems? NO ☐ YES ☐ Please specify ……………
Does your child wear glasses? NO ☐ YES ☐ ……………

CURRENT CLINICAL PICTURE
Is your child self-sufficient in personal care activities, dressing, and eating? NO ☐ YES ☐.
If not, please specify ……………
How would you describe your child's temperament ……………
Does your child have learning problems? NO ☐ YES ☐. If so, please specify when the learning problems began and briefly summarize your child's scholastic history: ……………
Main problems at the moment: ……………

DIAGNOSTIC EXAMS PERFORMED
Sleep-wake EEG: normal ☐ abnormal ☐. If abnormal, please specify ……………
Has your child undergone other types of investigations, for example, brain MRI, chromosome screening, etc. NO ☐ YES ☐ If so, which ones? ……………
Pharmacological treatment: YES ☐ NO ☐ If so, please specify ……………
Other (additional comments and notes about your child's development): ……………