Journal of Learning Disabilities
http://ldx.sagepub.com/

Syntactic Comprehension in Reading and Listening: A Study With French Children With Dyslexia

Séverine Casalis, Christel Leuwers and Heather Hilton

J Learn Disabil 2013 46: 210 originally published online 18 June 2012
DOI: 10.1177/0022219412449423

Article

Hammill Institute on Disabilities

Journal of Learning Disabilities
46(3) 210–219

DOI: 10.1177/0022219412449423
journaloflearningdisabilities.sagepub.com
SAGE

Syntactic Comprehension in Reading and Listening: A Study With French Children With Dyslexia

Séverine Casalis, PhD[1], Christel Leuwers, PhD[2], and Heather Hilton, PhD[3]

Abstract

This study examined syntactic comprehension in French children with dyslexia in both listening and reading. In the first syntactic comprehension task, a partial version of the Epreuve de Compréhension syntaxico-sémantique (ECOSSE test; French adaptation of Bishop's test for receptive grammar test) children with dyslexia performed at a lower level in the written but not in the spoken modality, compared to reading age–matched children, suggesting a difficulty in handling syntax while reading. In the second task, syntactic processing was further explored through a test of relative clause processing, in which inflectional markers could aid in attributing roles to the elements in a complex syntactic structure. Children with dyslexia were insensitive to inflectional markers in both reading and listening, as was the reading age control group, while only the older normal reader group appeared to make use of the inflectional markers. Overall, the results support the hypothesis that difficulties in comprehension in dyslexia are strongly related to poor reading skills.

Keywords

dyslexia, syntactic comprehension, gender agreement, phonological skills, spoken and written language

Dyslexia is defined as a specific disability in learning to read. It occurs in spite of normal schooling opportunities, normal intelligence, absence of sensorial deficit, and absence of psychiatric disease. This reading impairment is strongly linked to phonological deficits, which prevent children from developing an efficient word recognition system. As a consequence, many domains are likely to develop poorly, given that reading impacts cognitive and linguistic development (Vellutino, 1979). Developmental dyslexia could, for example, affect syntactic processing (Stein, Cairns, & Zurif, 1984), either as a primary deficit or indirectly through phonological or reading disabilities. An impoverished reading experience may limit the development of syntactic processing, since some complex structures are more likely to arise in writing than in speech. The aim of the present study was to examine syntactic comprehension in reading and in listening in order to probe the relationship between reading impairment, phonological impairment, and difficulties in syntactic processing.

The hallmark of dyslexia is a strong deficit in phonological processing, which is reflected in phonological awareness (Snowling, 2000; Swan & Goswami, 1997), phonological short-term memory (Snowling, 1981; Snowling, Nation, Moxham, Gallagher, & Frith, 1997; Sprenger-Charolles, Colé, Lacert, & Serniclaes, 2000), and naming speed (Wolf & Bowers, 1999). In most cases, the deficit appears even when dyslexic performance is compared with reading age–matched control children, suggesting that the deficit is not due to a lack of reading experience. Given that reading contributes to the development of many cognitive and linguistic skills (for its influence in phonological awareness, see Morais, Bertelson, Cary, & Alegria, 1986), an impairment that appears only in comparison with the chronological age group is difficult to interpret.

Spelling difficulties are frequently related to a complex array of graphemes corresponding to certain sounds and to the homophony of inflectional morphology. French has a rich inflectional morphology, though many forms are homophonic. The sound /e/, for example, is spelled differently depending on whether it is the infinitive verb form (-er), a past participle ending (é)—which may also take a (silent) plural or feminine ending (és, ée, ées)—or another tense or aspectual form, such as the *imparfait* (-ais, -ait, -aient), the

[1]Université Lille Nord de France, Villeneuve d'Ascq, France
[2]Université de Savoie, France
[3]Université Paris 8, Saint Denis, France

Corresponding Author:
Séverine Casalis, URECA, Université de Lille 3, Charles de Gaulle, BP 60149, 59653 Villeneuve d'Ascq, France.
Email: Severine.casalis@univ-lille3.fr

future (-ai), or the present (-ez), depending on verb subject. It is worth emphasizing that these word-final spelling variations (inflectional suffixes), particularly for verbs and adjectives, might help children process sentences to a greater extent in reading than in listening, since many of the morphemes are silent. These differences in oral and written inflectional morphology lead us to hypothesize that at least in French, performance in syntactic comprehension will differ according to modality.

Poor readers have been found to make comprehension errors with several syntactic constructions, including relative clauses (Shankweiler & Crain, 1986). Center-embedded and right-branching relatives were more difficult for poor third-grade readers to repeat and to comprehend, compared to good readers, in a study in which the complexity effect of the relative structure was the same for the two groups (Mann, Shankweiler, & Smith, 1984). In Grade 2, the performance of good readers fell to the level of poor readers when sentences contained phonetically confusable words (Mann, Liberman, & Shankweiler, 1980).

The difficulties of poor readers are considerably reduced when comprehension is tested by a task that minimizes demands on working memory. For example, sentence-picture matching tasks (simple or with two or four possible choices) reduce nonsyntactic processing demands, compared to an acting task (Macaruso, Shankweiler, Byrne, & Crain, 1993). These tasks eliminate the need to plan a response; the single-picture task requires only a go/no-go response (Shankweiler et al., 1995). With such tasks, poor readers succeed nearly as well as normal children (Bar-Shalom, Crain, & Shankweiler, 1993; Fowler, 1988; Macaruso et al., 1993; Smith, Macaruso, Shankweiler, & Crain, 1989). Shankweiler and colleagues (Mann et al., 1984; Shankweiler et al., 1995; Smith, Macaruso, Shankweiler, & Crain, 1989) hypothesize that syntactic difficulties in poor readers and people with dyslexia are caused by an underlying phonological deficit that impedes the temporary storage of verbal material. More recently, Robertson and Joanisse (2010) compared sentence comprehension (four-picture choice) in children with dyslexia and control age readers under three different working memory loads by varying the delay between the presentation of a sentence and the set of pictures. When pictures and spoken sentences are presented simultaneously, children can refer to the different pictures as they listen, and children with dyslexia and controls performed equally well. When a delay was introduced, performance of both groups decreased; however, only the children with dyslexia showed an effect of syntactic complexity in the delayed condition. The authors attribute this effect to greater limitations in verbal working memory.

Rispens and Been (2007) showed that Dutch children with dyslexia scored more poorly than typically developing children on a subject-verb agreement task. Interpreting associations between nonword repetition and sensitivity to subject-verb agreement, they suggest that poor morphosyntactic skills in dyslexia are due to poor phonological processing.

These various results seem to illustrate a deficit in syntactic processing for children with dyslexia. However, whether this deficit is a consequence of poor phonological skills, limited reading experience, or some other deficit, is not clear. Theoretically, syntactic difficulty could have different causes. It could stem from a phonological deficit, which makes it difficult to maintain the different bits of the sentence in working memory during syntactic processing, particularly in the case of embedded relatives, which “interrupt” the main clause. Phonological deficits could also generate difficulty in the processing of the syntactic markers, which involve a phoneme change. In both cases, people with dyslexia will be at a greater disadvantage in the written (rather than the oral) mode due to working memory overload.

Syntactic difficulty could also be a consequence of poor reading experience. Given their low reading level, children with dyslexia may be exposed to simple texts, containing fewer syntactically complex sentences; syntactic development may thus be delayed simply because children with dyslexia have not been exposed to the types of syntactically complex sentences that appear in more advanced written language. According to this hypothesis, performance in syntactic comprehension should depend on reading level.

Finally, we may also consider the possibility that children with dyslexia display a—slight—syntactic deficit per se, in addition to their phonological impairment. According to this hypothesis, they should be outperformed by reading age control groups in both listening and reading comprehension.

The present study aimed at examining these different hypotheses. Understanding syntactic difficulties in dyslexia is complicated by the fact that reading experience theoretically contributes to syntactic development (because written language contains more complex sentences) but may not be the sole source of development. We hope that a comparison between listening and reading performance will shed light on possible connections between listening and reading skill. For our study, the participants’ phonological skills were assessed in both modalities (written pseudoword decoding, oral pseudoword repetition, and phonological awareness tasks) in order to probe the connection between phonological skills and syntactic performance. We first assessed global level of syntactic comprehension both in reading and listening. We then examined more precisely how sensitive the children with dyslexia are to certain inflectional markers. As mentioned earlier, some syntactic markers in French may be seen *and* heard (*vert*/*verte*, green; masculine/feminine adjective agreement marker), seen and *not* heard (*bleu*/*bleue*, blue), or neither seen nor heard (*rouge*/*rouge*, red). Exploration of the sensitivity to these markers of feminine adjective agreement in both modalities may contribute to the comprehension of syntactic performance in dyslexia.

Method

Participants

Seventy-four children participated in the study: 27 children with dyslexia (hereafter DYS), 22 chronological age–matched children (hereafter CA), and 25 reading age–matched children (hereafter RA).

The children with dyslexia were patients consulting for learning disabilities at the Hôpital Roger Salengro (Lille, France). All had French as their first language and attended school regularly. They were diagnosed as developmental dyslexics by a multidisciplinary team including a pediatrician, a psychologist, and a speech therapist. All the children with dyslexia included in the study met the following criteria: reading age at least 2 years below the level expected for chronological age, normal IQ as assessed by the Wechsler scale (higher than 85), and absence of neurological disease or sensorial deficit. They all had normal to corrected vision. Children with attention deficit, specific language impairment, or psychiatric disease were excluded. Finally, all were enrolled in a reading remediation program, even though it was not a criterion for selection. Level of schooling in the children with dyslexia sample ranged from Grade 4 to Grade 7. The distribution of children with dyslexia across grades was the following: 12 were in Grade 4, 6 in Grade 5, 5 in Grade 6, and 4 in Grade 7.

IQ was assessed through the Wechsler scale (*L'Echelle d'intelligence de Wechsler pour enfants–Forme Révisée*; Wechsler, 1996). Mean IQ-P was 102 (range: 95-123). Mean verbal IQ was 95 (range: 85-103). Total IQ was computed for 20 children with dyslexia out of 27 and was 101 (range: 95-103).

The reading test used was *L'Alouette* (Lefavrais, 1967, 2005). In this test, children are requested to read aloud a text of 265 words as quickly and as accurately as possible. The final score provides a reading age, taking into account both speed (how many words are read in 3 minutes) and accuracy.

For inclusion in the control groups, children had to meet the following criteria. Their reading level corresponded to their chronological age, according to the *Alouette* test. Their nonverbal reasoning skills were not below the 25th percentile, as assessed by Raven's *Coloured Progressive Matrices* (Raven, Court, & Raven, 1995). They had to be native speakers of French. Parental consent was obtained before the experiment started.

In all, the children with dyslexia group had a chronological age mean of 10 years 6 months (range: 8 years 6 months-12 years 3 months), the CA group 10 years 3 months, and the RA group 7 years 8 months. Reading levels for these groups were, respectively, 7 years 6 months, 10 years 2 months, and 7 years 7 months. Thus, reading level was closely matched in the children with dyslexia and RA groups (t test, $p > .80$).

Materials

Phonological Tests

Pseudoword repetition. In this test, children are asked to pronounce a pseudoword after the experimenter has pronounced it. There are 30 items, with increasing difficulty in terms of length (from 2 to 5 syllables) and syllabic structure (CV, CVC, and CCV structures). Reliability for this test was .82.

Phoneme deletion. Children are requested to pronounce what remains after removing the first phoneme of a pseudoword. Items are monosyllabic and dissyllabic pseudowords beginning with a CV, CVC, and CCV syllable (30 items) initially pronounced by the experimenter. Reliability for this test was .78.

Oddity test. Children listen to a sequence of four words. All but one in each sequence begin with the same phoneme. Children have to pronounce the "odd word out"—the word beginning with a different phoneme. There are 16 items. Interrater reliability for this test was .72.

Pseudoword reading. Children are asked to read pseudowords that are printed on an A4 sheet of paper. There are 40 items of increasing difficulty, from two to four syllables long. The number of pseudowords correctly decoded constitutes the score. Cronbach's alpha was .83.

Irregular word reading. Children are asked to read irregular words printed on an A4 sheet of paper. There are 20 words that are considered as very to moderately familiar. The score is the number of irregular words correctly read. Cronbach's alpha was .67.

Syntactic Comprehension: ECOSSE-p. As a test of global syntactic comprehension, we used 32 items from the ECOSSE test (Lecocq, 1996). This is a French adaptation of the test for receptive grammar (TROG) by Bishop (1989). Once the sentence is heard or read, the children are shown four pictures and have to choose the one corresponding to the sentence. As distractors, there are pictures reflecting syntactic pitfalls and lexical distractors. Reading comprehension and listening comprehension are scored, according to the number of correct pictures chosen. There are 16 sentences for each modality in the ECOSSE partial test (hereafter ECOSSE-p). Sentences in the spoken and written modalities were strictly matched for syntactic structure, and no sentence was repeated across modalities. The sentences were selected from the most difficult items of the test, given the participants' age. We also excluded sentences that tapped pragmatic knowledge in order to focus on syntactic difficulty. The pattern of results obtained could therefore be due to the specificity of our syntactic tests, designed to exclude processing strategies involving semantic and pragmatic information as much as possible.

Table 1. Phonological Skill Score of Children With Dyslexia, Chronological Age–Matched Children, and Reading Age–Matched Children: Percentage of Correct Responses and *p* Values in Analysis of Variance (ANOVA) and Post Hoc Comparisons.

Task	DYS Mean Score	CA Mean Score	RA Mean Score	ANOVA *F* Value	DYS Versus CA	DYS Versus RA	CAC Versus RA
Pseudoword repetition	23.80	25.70	28.00	8.12**	*	*	*
Phoneme deletion	19.07	25.80	29.14	19.37**	**	**	**
Oddity	10.33	13.24	15.09	25.58**	**	**	**
Pseudoword reading	28.44	36.50	38.50	20.38**	*	*	*ns*

Note: DYS = children with dyslexia group; CA = chronological age–matched group; RA = reading age–matched children.
*$p < .05$. **$p < .01$.

Syntactic Comprehension: Relative Clauses. The experimental "relatives" test of syntactic comprehension is formally similar to the ECOSSE. All the sentences are Subject-Object relatives where first, the main clause is disrupted by the relative clause and second, the relativized noun is Subject of the main clause and Object of the relative clause. The relative clause describes an action involving two protagonists, who could be interchangeable; no pragmatic information determines the agent of the action. Finally, the main clause is constructed following the form *subject – copula + adjective*, and the general structure of the sentences is: (Noun1) which (Noun2) (Verb) is (Adjective); for example, *la poule que le coq pique est bleue* (the hen that the rooster is pecking is blue).

In French, the feminine adjective form is marked with the addition of a final "e." Depending on the final letter of the base form of the adjective, it will take on one of three forms, phonologically and/or orthographically.

In the "neutral" condition, the masculine form already ends with a final "e" so that the feminine form is indistinguishable from the masculine, both in writing and aurally, because nothing is added (e.g., *rouge*–red).

In the "orthographic" condition, the masculine forms ends with a vowel other than "e," so that an additional "e" is added (in writing) to mark the feminine form, but this addition will not be audible (e.g., *bleu* [masculine]/*bleue* [feminine]–blue)

In the "phonological" condition, the masculine forms ends with a consonant, so that the addition of a final "e" leads to a feminine marker that is both visible *and* audible: example: *vert* (masculine, the final –t is not articulated orally)/*verte* (feminine, the final –t is articulated, and an –e appears in writing).

In all of our experimental sentences there are two entities, a feminine and a masculine one. The feminine is systematically Noun 1, the masculine Noun 2.

> Example for the neutral condition: *la vache que le cheval poursuit est rouge* (the cow that the horse is chasing is red).
>
> Example for the orthographic condition: *la poule que le coq pique est bleue* (the hen that the rooster is pecking is blue).
>
> Example for the phonological condition: *l'oie que le chat regarde est verte* (the goose that the cat is watching is green).

There were 24 sentences in all, 12 in each modality, and 8 for each inflectional marker. For each sentence, four pictures were presented to the subject (*after* reading/listening), in only one of which the attributes of the protagonists correspond to the sentence; one of the three foils correspond to a misinterpretation of the main clause and the other two to a misinterpretation of the relative clause. In the written modality, the participants read the sentences aloud and then selected the appropriate picture; in the listening modality, the participants heard the sentence and then chose the picture. The score is the percentage of correctly selected pictures.

Characteristics of the Participants With Dyslexia

Given the prevalence of phonological deficits in dyslexia on the one hand and the heterogeneity of children with dyslexia on the other, it is important to collect additional data for each subject. We therefore assessed the phonological skills of our sample with dyslexia as a whole and compared their scores to those of both control groups.

The data collected with our phonological tests were used to compare the phonological skills of the children with dyslexia to those of both control groups. Scores were submitted to an analysis of variance (ANOVA), with groups DYS, CA, and RA the between-subject factor. Performance of the groups and summary of statistics are reported in Table 1.

Group performance differed on all the phonological measures. The children with dyslexia were outperformed not only by the CA children but also by the RA children in all the phonological measures. The difference between CA and RA children was significant as well, except for

Table 2. Percentage of Correct Responses in the ECOSSE Partial Test (ECOSSE-p; Standard Deviation in Parentheses).

Modality	DYS Mean Score	CA Mean Score	RA Mean Score
Written modality	78.00 (9.56)	94.00 (5.27)	85.00 (12.94)
Spoken modality	86.80 (10.15)	93.75 (6.68)	87.25 (10.50)

Note: DYS = children with dyslexia group; CA = chronological age–matched group; RA = reading age–matched children.

pseudoword repetition accuracy. These results demonstrate a clear phonological deficit for the dyslexic group.

Results

Do French Children With Dyslexia Display a General Delay in Syntactic Processing?

Our first aim was to examine whether children with dyslexia display a syntactic deficit when compared both to their chronological-age and their reading-age peers. We also wanted to examine to what extent any deficit observed is dependent upon the testing modality. We thus compared performance of the three groups (DYS, CA, and RA) in both modalities of the ECOSSE-p using an ANOVA, with modality (aural, written) as repeated measures. Comprehension performance is presented in Table 2.

There was a strong group effect, $F(2, 71) = 11.579$, $p = .000$, $\eta^2_p = .246$. Comprehension scores also differed according to modality, $F(1, 71) = 9.403$, $p = .003$, $\eta^2_p = .117$. The effect of modality differed across groups, as revealed by the modality by group interaction, $F(1, 71) = 5.401$, $p = .007$, $\eta^2_p = .132$.

We therefore explored the effect of modality in each group. In the children with dyslexia group, comprehension scores were higher in the spoken modality than in the written modality $t(26) = 5.72$, $p = .000$. By contrast, comprehension scores did not differ for the written or spoken modality in either of the control groups: $t(24) = .874$, $p = .39$ and $t(21) = .86$, $p = .17$ for the RA control and the CA control groups, respectively.

To test our hypotheses more directly, we compared the groups within each modality. In the spoken modality, groups significantly differed, $F(2, 71) = 3.27$, $p = .044$, $\eta^2_p = .084$. Tukey post tests indicated that the CA group outperformed both the RA and DYS groups, which did not differ. In the written modality, $F(2, 71) = 19.135$, $p < .001$, $\eta^2_p = .350$), Tukey post hoc tests indicated that the CA group outperformed the RA group, who in turn outperformed the DYS group.

Overall, our results point to a syntactic deficit in French children with dyslexia for their chronological age. The pattern is more subtle when reading level is considered. Children with dyslexia did not exhibit a syntactic deficit in listening when compared to RA children but showed significant difficulties in syntactic comprehension when reading sentences. Overall, the children with dyslexia performed worse in the written modality as compared to listening—a modality effect that did not appear in the control groups.

Do French Children With Dyslexia Benefit From Inflected Forms in Complex Sentence Processing?

As described previously, the nature of syntactic processing was further investigated through the use of sentences containing embedded relatives, in which inflected forms could sometimes be used to aid comprehension (enabling the reader/listener to attach an adjective to the correct noun). If children benefit from the inflected markers, the nature of the markers should impact their comprehension score. Neutral markers should lead to the lowest impact (since they are not informative), while orthographic markers should enhance reading comprehension, and phonological markers should enhance both reading and listening scores. We expect children with dyslexia to be less sensitive to these markers than control children.

A 3 (DYS, CA, or RA groups) × 2 (spoken, written modalities) × 3 (neutral, orthographic, or phonological markers) ANOVA was conducted on correct choice of pictures.

Comprehension scores varied across groups, $F(2, 71) = 8.45$, $p = .001$, $\eta^2_p = .192$. Post hoc analysis indicated that the DYS and RA groups did not differ, $p = .587$, while there were significant differences in comprehension scores across DYS and CA groups on the one hand and CA and RA groups on the other.

As a whole, there was no impact of modality ($F < 1$). However, the modality by group interaction was significant, $F(2, 71) = 5.865$, $p = .004$, $\eta^2_p = .142$, suggesting that the effect of modality differed across groups.

There was a significant effect of markers, $F(1, 71) = 7.64$, $p = .007$, $\eta^2_p = .097$. Comparisons indicated that comprehension scores were higher with phonological markers ($p = .05$). The interaction between markers and modality failed to reach significance, $F(1, 71) = 1.885$, $p = .174$.

To test our hypotheses, we compared the groups within each modality. In the written modality, groups differed significantly, $F(2, 71) = 15.41$, $p = .0001$, $\eta^2_p = .303$. Tukey posttests indicated that the CA group outperformed both the RA and DYS groups, which did not differ. In the spoken modality, groups differed only as a trend, $F(2, 71) = 2.422$, $p = .096$, $\eta^2_p = .064$. In pairwise comparisons, only the CA-RA groups differed, as a trend.

Table 3. Percentage of Correct Responses in the Relative Comprehension Task (Standard Deviation in Parentheses).

Group	Written Neutral	Written Orthographic	Written Phonological	Spoken Neutral	Spoken Orthographic	Spoken Phonological
DYS	46.30	44.44	50.00	49.07	59.26	57.41
	(20.38)	(23.75)	(23.37)	(25.18)	(28.39)	(28.13)
CA	71.59	76.14	81.82	60.23	59.09	71.59
	(28.39)	(23.36)	(22.45)	(28.86)	(30.00)	(27.95)
RA	49.00	49.00	46.00	45.00	44.00	55.00
	(29.98)	(32.02)	(27.73)	(32.87)	(30.34)	(29.26)

Note: DYS = children with dyslexia group; CA = chronological age–matched group; RA = reading age–matched children.

Given that comprehension scores differed across groups and that these differences further depended on modality, we conducted separate analyses for each participant group.

Children With Dyslexia. There was a strong effect of modality, with higher scores in the spoken modality as compared to the written modality, $F(1, 26) = 6.158$, $p = .02$, $\eta^2_p = .191$.

There was no significant effect of markers, $F(1, 26) = 1.565$, $p = 2.594$, $p = .119$, and no interaction between markers and modality ($F < 1$).

CA Group. There was a strong effect of modality, with higher scores in the written modality, compared to the spoken modality, $F(1, 21) = 7.692$, $p = .011$, $\eta^2_p = .268$.

The nature of the marker had a significant effect on comprehension scores, $F(2, 42) = 4.92$, $p = .012$, $\eta^2_p = .185$. However, there was no interaction between markers and modality, $F < 1$.

Comparisons revealed that comprehension scores were higher with phonological markers than for the two other types of markers, $t(21) = 2.78$, $p = .011$, $\eta^2_p = .182$; orthographic and neutral markers did not differ, $t(21) <$).

RA Group. There was no effect of modality, $F < 1$; no effect of markers, $F < 1$; and no interaction.

These results concerning the comprehension of complex sentences contribute new evidence for a syntactic deficit in French children with dyslexia when chronological age is considered. The performance of children with dyslexia was close to that of the RA children. Neither of these groups of children, contrary to the older children, took advantage of the syntactic information furnished by inflectional markers. However, while comprehension did not differ according to modality in younger normal readers, the children with dyslexia displayed higher aural than written comprehension.

How Are Syntactic Processing and Phonological Skills Connected in Dyslexia?

In order to investigate the connection between reading impairment, phonological skills, and syntactic comprehension, we computed correlations between phonological skills and syntactic comprehension. The correlation between syntactic comprehension scores and phonological ability scores is presented in Table 4.

Table 4. Correlation Between Syntactical Scores and Phonological Scores in the Children With Dyslexia Group.

Syntactical Score	PW Repetition	Phon Deletion	Oddity	PW reading
ECOS-O	.41*	.41*	41*	.39*
ECOS-E	.48*	.31	.36[a]	.40*
Age partialled out				
ECOS-O	.43*	.30	.31	.31
ECOS-E	.45*	.15	.23	.30

Note: PW repetition = pseudoword repetition; Phon Deletion = phoneme deletion; PW reading = pseudoword reading; ECOS-O = ECOSSE, spoken modality; ECOS-E = ECOSSE, written modality

[a] $p < .10$.
*$p < .05$.

Correlations were found between phonological abilities on the one hand and single item reading on the other hand. These correlations survive when correlation with age is partialled out. This strongly suggests that the difficulties in syntactic processing are related to phonological processing.

Discussion

Our study aimed at examining whether or not children with dyslexia show a deficit in syntactic comprehension. Given that syntactic development may depend to a certain extent on reading experience, we compared dyslexic performance with both chronological and reading age control groups and comprehension in both reading and listening. As mentioned in the introduction, the comparison between children with dyslexia and reading age–control children is crucial in determining whether children with dyslexia present a syntactic deficit in addition to their reading and/or phonological impairments. The rationale is the following: Lower performance by children with dyslexia than reading age controls in a complex sentence comprehension task provides evidence for a syntactic deficit that is not accounted for by reading or phonological impairment; if children with dyslexia perform at least at the same level, it cannot be argued that they present an additional deficit in syntactic skills. Considering the modality is central too, for if there is a syntactic deficit in dyslexia, it should be observed in both reading and listening—in other words, independently of modality. In the present study, two tests were used to assess syntactic processing: a partial version of the ECOSSE test and a test assessing the comprehension of relative clauses, which focused on the processing of feminine adjective endings during comprehension of sentences containing an embedded relative clause. Three cases were considered: the neutral condition (where no marker distinguishes feminine from masculine adjectives), the orthographic condition (where the final mute "e" for the feminine form is visible but not audible), and the phonological condition (where the feminine marker is both visible and audible).

Overall, our results illustrate a syntactic deficit in French children with dyslexia compared to their chronological age peers; this deficit is found in both reading and listening comprehension. This supports the view that reading experience contributes to overall language development. When the children with dyslexia were compared with reading level controls, a more complex pattern emerged. In the ECOSSE-p test, children with dyslexia performed more poorly than reading age–matched children in reading comprehension and comparably in listening comprehension. Even though it is difficult to interpret absence of effect, this pattern allows us to rule out the hypothesis of a purely syntactic deficit in dyslexia, given the discrepancy between listening and reading performance. This point will be discussed in the following.

The relative clause test also revealed a deficit in children with dyslexia scores compared to the chronological age–matched subjects. By contrast, children with dyslexia performance was comparable to that of the reading age–control children. This test of complex syntactic processing was designed to investigate the subjects' sensitivity to feminine markers. Data clearly indicate that the level of comprehension of the children with dyslexia did not differ according to the different types of adjective markers, illustrating their lack of sensitivity to these markers, in both modalities. This lack of sensitivity was not specific to the children with dyslexia, since the RA children did not rely on the markers either. The comprehension of chronological age–matched children, by contrast, improved when phonological markers were present. This would appear to indicate that sensitivity of this type develops later in these French children.

Our data bring new evidence of syntactic difficulties in both listening and reading comprehension. In both tests, modality interacted significantly with group. While chronological age–matched children scored higher in reading than in listening comprehension, the reverse was observed in the children with dyslexia group. The reading age control group exhibited an intermediate position, with equivalent listening and reading comprehension scores. It appears that in normal development, the comprehension of syntactically complex sentences improves progressively and that normal readers are gradually able to use morphological information to help with complex syntactic processing. This pattern is not observed in children with dyslexia, perhaps because children with dyslexia cannot deal with simultaneous demands in both syntactic processing and reading. Correlations computed in the children with dyslexia group indicate a link between pseudoword repetition and syntactic comprehension.

Given that some null results appeared in our study, we have to check carefully whether methodological and statistical requirements were fulfilled. The chronological age control group attained high scores, near ceiling values, thus limiting some conclusions. However, if this is true for Experiment 1, where the group reached 95% of correct responses, it is not the case for Experiment 2, where correct responses fall to 70%. In addition, it was not the case for the reading age control group, which performed at the same level as the children with dyslexia group. Thus, we have valid indicators that the development of syntactic comprehension differs in the children with dyslexia group given their age.

The results of the relative clause test indicate that unlike the chronological age control group, the children with dyslexia and reading age–matched groups do not take advantage of morphosyntactic gender markers on final adjectives, which, nevertheless, help to disambiguate their referent (the initial noun). In spite of the low number of items, an effect of adjective ending was observed in the chronological age control group, but the small number of items in each experimental condition might have prevented an interaction between modality and markers from manifesting itself. Future studies will need to include more test items.

The lack of effect of morphosyntactic cues for the children with dyslexia group cannot be explained by their level of performance. The sentences were relatively difficult to understand (no ceiling effect), but not too difficult, since we did not observe floor effects either. The four-picture task we chose imposes stronger demands on working memory—the child is required to retain the input string in working memory long enough to derive an interpretation and match it to the appropriate picture (Macaruso et al., 1993). The task sentences describe implausible events, so that syntactic processing cannot be assisted by semantic processing (Byrnes, 1981); in addition, the relative clause structure used (Subject-Object center-embedded relatives) is one of the most difficult, even for children with no reading problems (Bar-Shalom et al., 1993; Crain, Shankweiler, Macaruso, & Bar-Shalom, 1990; Mann et al., 1984).

Other features ensured that the task was not too difficult. In the embedded relatives used (*la poule que le coq pique est bleue*; the hen that the rooster is pecking is blue), the subject of both verbs (*pique, est*) is the closest noun (*le* *coq*); additional syntactic information is provided by the relative pronoun itself, *que*, which can only have an object function in French (*qui* being used for subject relatives). The structure of the main clause was simple (Noun1 + copula + adjective) and stable; only two animate nouns were used (three having been shown to create comprehension problems; Goodluck & Tavakolian, 1982); we also chose nouns for which there is a transparent relation between the gender of the noun and of the referent, like *hen* (Vigliocco & Franck, 2001). As Vigliocco and Franck (1999) have noted, in subject-predicate adjective gender agreement, syntactic information is primary and can be strengthened by redundant conceptual information; these redundant sources of information may protect against information loss during comprehension.

In spite of the intermediate level of performance observed here, there was no indication of the use of morphosyntactic gender markers by our children with dyslexia group. This was also the case for the reading age control children, so we cannot conclude that only children with dyslexia have this particular deficit. Other studies have concluded that children with dyslexia are weaker in the morphosyntactic domain. Rispens and Beens (2007) found lower sensitivity to number agreement in children with dyslexia compared to chronological control readers. Note, however, there is no comparison to a reading age control group. Jiménez et al. (2004) have shown that when working memory is controlled, performance in sentence comprehension in Spanish did not differ between groups of children with dyslexia, age control, and reading control children when the correct response requires the processing of word order or function words. However, children with dyslexia performed more poorly than the two control groups when processing gender or number agreement was required. It is worth noting that in this study, sentence comprehension was assessed in reading only; so whether the deficit is general or specific to reading remains unclear.

We are left with our central question, whether or not there is evidence for a syntactic deficit in children with dyslexia. The pattern of the present study clearly indicates a discrepancy between the written and spoken modalities. These results are puzzling since no difference emerged between children with dyslexia and RA children, except in one situation, namely, the written part of the ECOSSE-p. In the other tests (the spoken ECOSSE-p and both spoken and written relative clause tests), we did not find any indication of a syntactic deficit beyond the reading impairment. Why this discrepancy between tests? It is perhaps important to bear in mind that the fact that the RA and children with dyslexia groups that are matched in reading level does not necessarily imply that they are matched in their exposure to written language. Children with dyslexia—particularly the older ones and those having received special remedial training—may have encountered oralized examples of more complex written structures. Thus, children with dyslexia might be more familiar with some complex structures and may develop syntactic abilities in spoken language. This may explain why they are not outperformed by reading age controls in the spoken modality. Since relative clauses are acquired relatively late, the older children with dyslexia could be more familiar with these structures than the younger reading age controls. Finally, even though our results suggest some difficulties for the children with dyslexia, they do not provide evidence of a genuine deficit, since children with dyslexia performance should be lower than RA controls if this were the case, in particular when the structures are particularly difficult.

Another puzzling result is precisely that the difficulties of the children with dyslexia are apparent in the ECOSSE-p test and not in the relative clause test—the relative should be more difficult to process, and acquired later, than the structures involved in the ECOSSE-p. We have various suggestions as to why this was not the case.

The relative clause examines whether children can take gender marks into account in order to assist syntactical processing, which neither the children with dyslexia nor the RA-matched children were able to do. The ECOSSE-p directly assesses the comprehension of syntactic structure, and here the children with dyslexia performed lower than the RA control, but in the written modality only. Close examination indicates that about 40% of the sentences include a nominal phrase marked in gender or in number. Many errors committed by the children with dyslexia show that they did not pay attention to the ends of words when reading. Even though they are matched with the reading age children on word recognition, the children with dyslexia may be less prone to pay attention to letters at the end of a word once the lemma has been identified. In other words, they do not process morphosyntactic markers when reading. This could explain why children with dyslexia perform higher in listening comprehension while CA children perform higher in reading comprehension and constitutes one of our major findings of this study. In older normal readers, syntactic comprehension is better in the written modality probably because the morphosyntactic markers can be seen, even when they cannot be heard. This would encourage the children to a higher focalization on these marks. The children with dyslexia, by contrast, do not appear to pay attention to or benefit from this written information to boost their syntactic comprehension. This could be a result of the transferral of oral processing strategies (in which fewer phonological cues are available, making endings unreliable syntactic aides); alternatively, it could be due to working memory overload—with visual decoding processes absorbing the resources that better readers can allow to analyzing the additional syntactic information the endings provide. Younger children—the RA group—have an intermediate position; perhaps their grammatical training has not yet reached the point where they can take advantage of the additional information provided by the adjectives that are useful only in writing (our "orthographic" condition).

An offline measure of comprehension is probably not sufficient to decide between hypotheses. Recently, the analysis of online processing in listening comprehension in children with comprehension difficulties was conducted by Nation, Marshall, and Altmann (2003), using the "visual world" paradigm (Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995), where language-mediated eye movements are taken to reflect the cognitive processes that underpin the real-time processing of language and the mapping of that language onto a concurrent visual world.

Nation et al. (2003) used this paradigm to analyze whether children, like adults (Altmann & Kamide, 1999), extract information from a verb and use this information to guide ongoing processing by predicting subsequent references to those objects in the visual context that satisfy the verb's selectional restrictions. They analyzed eye movements to a visual target object (a cake) in a visual scene listening to two sentences, in which only the verb differs (*Jane watched her mother eat/choose the cake*). The visual context was supportive for the first verb (the cake was the only edible object in the scene) and neutral for the other (all of the objects were chooseable). The results showed that eye movements to the visual target object were launched earlier in the supportive context than in the neutral context. This gives evidence of sensitivity to verb selection restrictions and to the participants' ability to integrate this with information extracted from "real-world" visual context.

With such a paradigm, online processes can be registered without additional working memory task demands, so that children with dyslexia would not be doubly penalized. Analyses of online processes during the deployment of sentences would reflect deviant syntactic processing in children with dyslexia—if it occurs—and possibly enable us to pinpoint the locus of this deviance.

In conclusion, our results indicate that the syntactic deficit in dyslexia is mainly connected to reading level even though some difficulties are not completely explained by reading delay. Our results also support the processing limitation hypothesis (Shankweiler et al., 1995), which suggests that poor syntactic comprehension by children with dyslexia is due to an overload of working memory during sentence processing. This may be related to phonological impairments, as attested by lack of sensitivity to feminine markers. The fact that the performance of our participants was better in the oral than in the written modality suggests that the working memory demands generated during the reading process interferes with written comprehension more than listening. Finally, our results indicate the importance of considering simultaneously written and spoken comprehension in order to improve our understanding of linguistic processing in dyslexia.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

This research was supported by the program "Cognitique: les apprentissages et leurs dysfonctionnements [learning and learning disabilities]" : Comparaison de populations de mauvais lecteurs et impacts d'entrainements spécifiques sur la comprehension orale et écrite" awarded to Christel Leuwers.

References

Altmann, G. T. M., & Kamide, Y. (1999). Incremental interpretation at verbs: Restricting the domain of subsequent reference. *Cognition, 73*, 247–264.

Bar-Shalom, E., Crain, S., & Shankweiler, D. (1993). A comparison of comprehension and production abilities of good and poor readers. *Applied Psycholinguics, 14*, 197–227.

Bishop, D. (1989). *Test for reception of grammar*. London: Medical Research Council.

Byrnes, B. (1981). Deficient syntactic control in poor readers: Is a weak phonetic memory code responsible? *Applied Psycholinguistics, 2*, 201–212.

Crain, S., Shankweiler, D., Macaruso, P., & Bar-Shalom, E. (1990). Working memory and comprehension of spoken sentences: Investigations of children with reading disorder. In G. Vallar & T. Shallice (Eds.), *Neuropsychological impairments of short-term memory* (pp. 477–507). Cambridge, UK: Cambridge University Press.

Fowler, A. (1988). Grammaticality judgments and reading skill in Grade 2. *Annals of Dyslexia, 38*, 73–94.

Goodluck, H., & Tavakolian, S. (1982). Competence and processing in children's grammar of relative clauses. *Cognition, 11*, 1–27.

Jiménez, J. E., García, E., Estévez, A., Díaz, A., Guzmán, R., Hernández-Valle, I., . . . Hernández, S. (2004). A comparison of comprehension and production abilities of good and poor readers. *Electronic Journal of Research in Educational Psychology, 2*, 127–142.

Lecocq, P. (1996). *L'E.CO.S.SE : une épreuve de compréhension syntaxico-sémantique* [A syntactical semantic comprehension test]. Villeneuve d'Ascq: Presses Universitaires du Septentrion.

Lefavrais, P. (1967). *Test de l'Alouette: Manuel* [The Larkin Test]. Paris: Les Editions du Centre de Psychologie Appliquee.

Lefavrais, P. (2005). *Test de l'Alouette-R: Manuel* [The Larkin Test]. Paris: Les Editions du Centre de Psychologie Appliquee.

Macaruso, P., Shankweiler, D., Byrne, B., & Crain, S. (1993). Poor readers are not easy to fool: Comprehension of adjectives with exceptional control properties. *Applied Psycholinguistics, 14*, 285–298.

Mann, V. A., Liberman, I. Y., & Shankweiler, D. (1980). Children's memory for sentences and word strings in relation to reading ability. *Memory and Cognition, 8*, 329–335.

Mann, V. A., Shankweiler, D., & Smith, S. T. (1984). The association between comprehension of spoken sentences and early reading ability: The role of phonetic representation. *Journal of Child Language, 11*, 627–643.

Morais, J., Bertelson, P., Cary, L., & Alegria, J. (1986). Literacy training and speech segmentation. *Cognition, 24*, 45–64.

Nation, K., Marshall, C. M., & Altmann, G. T. M. (2003). Investigating individual differences in children's real-time sentence comprehension using language-mediated eye movements. *Journal of Experimental Child Psychology, 86*, 314–329.

Raven, J. C., Court, J. H., & Raven, J. (1995). *Raven manual: Coloured progressive matrices*. Oxford, UK: Oxford Psychologists Press.

Rispens, J. E., & Been, P. H. (2007). Subject-verb agreement and phonological processing in developmental dyslexia and SLI: A closer look. *International Journal of Language and Communication Disorders, 42*, 293–305.

Robertson, E. K., & Joanisse, M. F. (2010). Spoken sentence comprehension in children with dyslexia and language impairment: The roles of syntax and working memory. *Applied Psycholinguistics, 31*, 141–165.

Shankweiler, D., & Crain, S. (1986). Language mechanisms and reading disorder: A modular approach. *Cognition, 24*, 139–168.

Shankweiler, D., Crain, S., Katz, L., Fowler, A. E., Liberman, A. M., Brady, S. A., . . . Shaywitz, B. A. (1995). Cognitive profiles of reading-disabled children: Comparison of language skills in phonology, morphology, and syntax. *Psychological Science, 6*, 149–156.

Smith, S. T., Macaruso, P., Shankweiler, D., & Crain, S. (1989). Syntactic comprehension in young poor readers. *Applied Psycholinguistics, 10*, 429–454.

Snowling, M. (2000). *Dyslexia* (2nd ed.). Oxford, UK: Blackwell.

Snowling, M. J. (1981). Phonemic deficits in developmental dyslexia. *Psychological Research, 43*, 219–234.

Snowling, M., Nation, K., Moxham, P., Gallagher, A., & Frith, U. (1997). Phonological processing skills of dyslexic students in higher education: A preliminary report. *Journal of Research in Reading, 20*, 31–41.

Sprenger-Charolles, L., Colé, P., Lacert, P., & Serniclaes, W. (2000). On subtypes of developmental dyslexia: Evidence from processing time and accuracy scores. *Canadian Journal of Experimental Psychology, 54*, 87–104.

Stein, C. L., Cairns, H. S., & Zurif, E. B. (1984). Sentence comprehension limitations related to syntactic deficits in reading-disabled children. *Applied Psycholinguistics, 5*, 305–322.

Swan, D., & Goswami, U. (1997). Phonological awareness deficits in developmental dyslexia and the phonological representations hypothesis. *Journal of Experimental Child Psychology, 66*, 18–41.

Tanenhaus, M. K., Spivey-Knowlton, M. J., Eberhard, K. M., & Sedivy, J. C. (1995). Integration of visual and linguistic information in spoken language comprehension. *Science, 268*, 1632–1634.

Vellutino, F. R. (1979). *Dyslexia: Theory and research*. Cambridge, MA: MIT Press.

Vigliocco, G., & Franck, J. (1999). When sex and syntax go hand in hand: Gender agreement in language production. *Journal of Memory and Language, 40*, 455–478.

Vigliocco, G., & Franck, J. (2001). When sex affects syntax: Contextual influences in sentence production. *Journal of Memory and Language, 45*, 368–390.

Wechsler, D. (1996). *W.I.S.C.-R: L'Echelle d'intelligence de Wechsler pour enfants* (Forme Révisée) [Wechsler Intelligence Scale for Children]. Paris: Editions du Centre de Psychologie Appliquée.

Wolf, M., & Bowers, P. G. (1999). The double-deficit hypothesis for the developmental dyslexias. *Journal of Educational Psychology, 91*, 415–438.