Research in Developmental Disabilities 35 (2014) 3313–3325

Contents lists available at ScienceDirect

Research in Developmental Disabilities

Word and pseudoword reading in children with specific speech and language impairment

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ARTICLE INFO

Article history:
Received 30 April 2014
Received in revised form 25 July 2014
Accepted 29 July 2014
Available online

Keywords:
Specific language impairment
Reading aloud
Phonological procedure
Orthographic procedure

ABSTRACT

Children with specific language impairment frequently encounter difficulties in learning to read and in particular, in word recognition. The present study set out to determine the precise impact of language impairment on word reading skills. We investigated single-word reading in 27 French children with specific speech and language impairment (2SLI). Precise quantification of reading levels in the 2SLI group showed an average delay of 3.5 years. Approximately 90% of these children were affected by a reading disorder, whereas for the remaining 10%, reading performance was within normal limits. Word reading procedures are analyzed using the so-called 'dual route model', which proposes that reading is achieved through two processes, the phonological and the orthographic procedures. Group comparison analyses of 27 reading level-matched control children, revealed an increased lexicality effect in the 2SLI group, indicating a specific deficit in the phonological procedure. Moreover, multiple case analyses revealed interindividual differences among the children with 2SLI, with four reading subtypes. Approximately 60% of these children reached the standard levels expected of younger children with identical reading levels (delayed reading profile) in both procedures. Twenty percent displayed qualitatively different reading mechanisms, with a greater deficit in the phonological procedure (phonological profile). These children showed a severe impairment in language production at the phonological level. Ten percent exhibited a greater orthographic deficit (surface profile) and 10% had normal reading skills (normal profile). Further research is required to improve our understanding of the relationships between 2SLI or specific language impairment and reading acquisition. The present results suggest that in clinical practice, both reading procedures should be exercised, with emphasis on the phonological procedure for children with more severe deficits in phonological production.

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http://dx.doi.org/10.1016/j.ridd.2014.07.058
0891-4222/

1. Introduction

1.1. Specific language impairment

Specific language impairment (SLI) is a disorder affecting language comprehension and/or production, which occurs in children with no serious sensory or nonverbal intellectual disability, brain damage, or psycho-affective or neurological disease (Bishop, 1997; Leonard, 1998, 2000; Schwartz, 2009). Language disorders in SLI are heterogeneous (Bishop & Snowling, 2004; Botting & Conti-Ramsden, 2004; Evans, 1996; Leonard, 2009), with a wide range of clinical manifestations that vary depending on which specific fields of language (phonology, morphosyntax, semantics, and pragmatics) are selectively or simultaneously affected. Given the relationship between spoken and written language, children with SLI are at high risk of literacy disabilities. They encounter difficulties in phonological awareness (Claessen & Leitão, 2012), reading (McArthur, Hogben, Edwards, Heath, & Mengler, 2000), spelling, and written narrative skills (Bishop & Clarkson, 2003; Broc et al., 2013). The aim of the present study was to conduct an in-depth investigation of reading-aloud mechanisms in these children.

1.2. Reading

Most research into reading acquisition is based on the general framework of the 'simple view of reading' proposed by Gough and Tunmer (1986) according to which, reading comprehension is the product of two components: word decoding and listening comprehension. Therefore, written comprehension skills cannot be clearly understood without a clear understanding of the written-word identification level.

One of the prevailing models used for studying written-word identification skills is the 'dual-route model' (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001), which stipulates that reading aloud is achieved through two procedures. On the one hand, the phonological (sublexical) procedure uses knowledge of grapheme–phoneme correspondence rules, which enable children to read pseudowords (items that do not belong to their mother tongue e.g., *napo*) and unknown regular words (words that respect these rules e.g., *crib*). On the other hand, by directly accessing the written-word representation stored in the orthographic lexicon, the orthographic (lexical) procedure makes it possible to read known, regular words, such as *cat*, and irregular words, which are words that do not respect the grapheme–phoneme conversion rules (e.g., *yacht*). Although most disabled readers display deficits in both procedures, some developmental dissociations may be evidenced (Sprenger-Charolles, Lacert, Béchennec, Colé, & Serniclaes, 2001). Depending on which deficit is identified, one of two types of reading disorder can be diagnosed; phonological and surface disorders correspond to a predominantly phonological or orthographic procedure deficit, respectively.

1.3. Written word identification assessment

Two complementary methods are frequently used to evaluate single word reading skills in children with a reading disorder.

The first method is group comparison analysis, whereby performance of children with a reading disorder, as a group, is compared with that of children with typical development. Performance with regard to the phonological procedure is generally assessed by measuring two effects: The lexicality effect compares word versus pseudoword reading skills, whereas the length effect compares performance on short versus long items (words or pseudowords). In contrast, the regularity effect serves to assess the orthographic procedure: Performance in reading regular words is compared with that of irregular words. Lexicality and length effects are stronger in children with a phonological procedure deficit (e.g., dyslexic children) than in controls (Martens & de Jong, 2006; Rack, Snowling, & Olson, 1992). Indeed, pseudoword reading deficits are more pronounced than word reading deficits in dyslexic children; the reading deficit in terms of long items (words or pseudowords) is greater than that for short items, indicating an extremely slow phonological decoding mechanism (Ziegler, Perry, Ma-Wyatt, Ladner, & Schulte-Körne, 2003). In the event of impaired orthographic procedure, the regularity effect is greater (Sprenger-Charolles & Colé, 2013); the reading deficit in terms of irregular words is more pronounced than that for regular words. However, such group analyses give no indication of whether the results reflect the skills of most children or just those of one subgroup.

The second method, multiple case analysis, fills this gap by identifying reading-disorder subtypes and their prevalence (Castles & Coltheart, 1993; Manis, Seidenberg, Doi, McBride-Chang, & Petersen, 1996; Sprenger-Charolles, Siegel, Jiménez, & Ziegler, 2011). This has led to the identification of three reading profiles. The first subgroup includes children with a delayed reading profile, that is, for both procedures, their reading performance is similar to that of younger children with typical development. The second and third subgroups correspond to children with phonological and surface reading disorders, respectively.

1.4. Reading in children with SLI

As mentioned in Section 1.1, children with SLI frequently suffer from reading disorders. Prevalence data from several studies show large discrepancies, ranging from 12.5% to 85% (McArthur et al., 2000), with figures for reading disorders and

SLI of similar magnitude. The more severe, extensive (several areas affected), and persistent the spoken language impairment, the greater the likelihood of observing a severe reading disorder (Bishop, 2001; Catts, Fey, Tomblin, & Zhang, 2002; Conti-Ramsden, Botting, Simkin, & Knox, 2001; Simkin & Conti-Ramsden, 2006; Snowling, Bishop, & Stothard, 2000; Vandewalle, Boets, Boons, Ghesquière, & Zink, 2012). Reading disorders affect both components of reading: word identification and reading comprehension, the latter being more frequently and more severely impacted (Bishop & Adams, 1990; Conti-Ramsden, Botting, Simkin, & Knox, 2001; Simkin & Conti-Ramsden, 2006). Although children with SLI show lower initial reading achievement compared to control children, they show similar progress over the first ten school years (Catts, Bridges, Little, & Tomblin, 2008).

1.5. Limitations of previous studies on reading in children with SLI

Currently, there is no clear, comprehensive overview of the reading skills of children with SLI, for four reasons.

Firstly, currently available studies on written-word identification in SLI are not based on a theoretical framework such as the dual-route model that is likely to account for the reading-disorder mechanisms. Secondly, as suggested by Bishop and Snowling (2004), there has been no attempt to classify children with SLI according to their type of word reading identification. In the present study, we will try to compensate for both shortfalls.

Thirdly, there are large discrepancies between the prevalence data in most studies. As mentioned by Simkin and Conti-Ramsden (2006), this can be explained by the considerable heterogeneity of the methodologies used. In particular, cohorts differ with regard to age of participants and level of speech-language therapy (absence or presence, frequency, and nature of therapy). In addition, criteria used to substantiate SLI and reading disorders may vary between studies (pathological thresholds, number, and type of language areas assessed).

Fourthly, SLI itself is heterogeneous and studies do not always precisely describe the spoken language characteristics of the population investigated. Spoken and written language skills are closely related, and different forms of SLI are likely to lead to different reading profiles (Simkin & Conti-Ramsden, 2006). It is generally accepted that written-word identification is mainly related to phonological skills, whereas written comprehension is more broadly related to spoken language skills, such as vocabulary, morphosyntax, and discourse (Colé et al., 2012).[1] Therefore, in order to make an accurate assessment of the reading skills of children with SLI, it is essential to identify whether the deficit is limited to mere language impairment or whether it affects both phonology and language. A few studies have indeed distinguished between the two kinds of deficit (e.g., Bishop, McDonald, Bird, & Hayiou-Thomas, 2009). However, many provide incomplete information about phonological skills, making it difficult to ascertain how many of the children with SLI enrolled in the study have a language impairment alone and how many have both phonological and language impairments (Specific Speech and Language Impairment: 2SLI). For example, with regard to the phonological level, only metaphonology and/or rapid naming skills are assessed, but not phonological production. Thus, the incomplete description of spoken language characteristics – including speech – in children with SLI makes it difficult to characterize their reading skills, in light of their spoken language abilities.

In this study, data on spoken language skills are provided, with regard to both phonological and language levels: All children with SLI have 2SLI, which is a particularly severe and frequent impairment (Pennington & Bishop, 2009).

1.6. Aims of the present study

Our study pursued two aims.

1. The first was to conduct an in-depth investigation of reading aloud in children with 2SLI: firstly, to accurately quantify reading levels; secondly, to analyze word reading procedures within the dual-route framework; and thirdly, to assess potential interindividual heterogeneity through multiple case analyses by subtyping reading disorders.
2. The second aim was to investigate how speech and spoken language, including general and reading-related skills, are related to reading aloud in children with 2SLI: firstly, by comparing children with 2SLI with reading level (RL)-matched control children; secondly, by comparing the different reading disorder subtypes in children with 2SLI.

2. Method

2.1. Participants

2.1.1. Children with 2SLI

Twenty-seven children with 2SLI were enrolled in this study. They were aged between 7.70 and 12.90 (average age, 10.95). All had previously been diagnosed with SLI by a multidisciplinary team. The diagnosis was based on a clinical examination that included auditory and visual assessments, speech and language evaluation, and measurements of

[1] For the sake of clarity, and in line with the terminology presented and discussed by Leonard (1998), 'language skills' will refer to vocabulary, morphosyntax and discourse levels, while 'speech skills' will refer to phonology.

neuropsychological performance. Participants all had nonverbal intellectual performance within normal limits. There was no evidence of auditory impairment, or neurological or psychological disorders that could explain the language deficit.

In most English-language studies, inclusion criteria are based on Leonard's recommendations (Leonard, 1998): A child is identified as presenting an SLI when at least two composite scores fall below −1.25 SD. In French language batteries, however, only subtest scores are available, so Leonard's recommendations cannot be adapted to French tests. We therefore introduced criteria that are more suited to the tools presently available in the French language.

The pathological threshold was fixed at −1.65 SD because this corresponds to the 5% cut-off generally used in group analyses. Indeed, this threshold is widely used in written language studies (Casalis, 2003; Ramus et al., 2003; White et al., 2006; Ziegler et al., 2008), and our work required the threshold to be appropriate for both oral and written language assessments. It stands between the severe threshold of −2 SD (Whitehurst & Fischel, 1994; World Health Organization, 1993) and the milder one of −1 SD (Weismer, Evans, & Hesketh, 1999).

To be included in the study, children with 2SLI had to obtain pathological scores in at least pseudoword and sentence repetition tasks on the *Langage oral, Langage écrit, Mémoire, Attention, 2ème édition* test (Oral language, Written language, Memory, and Attentional skills. Second edition, L2MA-2, Chevrie-Muller, Maillart, Simon, & Fournier, 2011), because these give an accurate distinction between children with SLI and those with typical development (Archibald & Joanisse, 2009; Coady & Evans, 2008; Conti-Ramsden, Botting, & Faragher, 2001; Maillart, Leclercq, & Quémart, 2012; Riches, 2012; Thordardottir et al., 2011).

2.1.2. Reading level-matched control children

The control group for group analyses was made up of 27 children. As our aim was to examine reading processes in 2SLI, we decided to establish the matching on the basis of the reading level (RL). RL-matched control children were aged between 6.25 and 11.48 (average age, 7.84). All were attending school in the class corresponding to their age (i.e., between first and fifth grade of elementary school). Parents provided confirmation that none of the children had a history of speech, language or hearing difficulties. To ensure that these children were indeed within the normal limits in terms of spoken language, several language tests were administered (see Section 2.2.1.1). All performed higher than −1.25 SD. This limit is higher than the pathological threshold of −1.65 SD chosen for children with 2SLI and was used to clearly distinguish the spoken language-skill impairment of the 2SLI group from the typically normal skills of the control group. With regard to written language skills, none of the control children were dyslexic, as confirmed by their results on the Alouette test (Lefavrais, 1967, see Section 2.2.2.1). More specifically, none displayed a reading delay greater than 14 months, whereas the pathological threshold for dyslexia is between 18 and 24 months (Casalis, 2004). Children from the control group were matched to children from the 2SLI group on the percentage, $t(52) < 1$, *ns*, and the latencies, $t(50) < 1$, *ns*, of correctly read regular words from the *EVAluation de la LECture* (Reading Evaluation) computerized reading battery (EVALEC, Sprenger-Charolles, Colé, Béchennec, & Kipffer-Piquard, 2005; Sprenger-Charolles, Colé, Piquard-Kipffer, & Leloup, 2010) and on the scores of the Alouette text reading-aloud test, for objective scoring, $t(52) < 1$, *ns*, and for subjective scoring, $t(52) < 1$, *ns* (see below Section 2.2.2.1). Both groups were also strictly matched for gender (20 boys and seven girls per group).

2.1.3. Common features of 2SLI and RL-matched control children

Children were all monolingual French speakers. Their nonverbal intellectual skills were shown to be normal, with scores higher than the 10th percentile on the matrix reasoning subtest of the Wechsler Nonverbal Scale of Ability (WNV, Wechsler & Naglieri, 2009). Parents all signed an informed consent allowing their children to take part in the study. They were informed that their children could withdraw from the study at any time, without any justification, and that any information collected would be processed anonymously. The children gave oral consent.

2.2. Materials

In both groups, several tests were used to assess speech, spoken language skills (including general measures as well as reading-related measures) and reading.

2.2.1. Speech and spoken language skills

2.2.1.1. General measures. Phonological skills. The repetition subtest of the standardized L2MA-2 battery (Chevrie-Muller et al., 2011) includes 20 pseudowords. Children were first presented with 10, simple, consonant-vowel structures, followed by 10 pseudowords with a more complex consonant-consonant-vowel and consonant-vowel-consonant structure. Pseudowords were presented progressively from the shortest (two syllables) to the longest (five syllables).

To reinforce the accuracy of the measurement, we developed a repetition test of 20 pseudowords followed by 20 familiar words. Items were one to five syllables long. Internal consistency was high (Kuder–Richardson Formula 20, for pseudowords: 0.82, for words: 0.79).

Stimuli were pre-recorded on a digital support and presented to the child via a laptop computer and a Sennheiser HD 595 headset. Answers were recorded on a digital dictaphone and later written down using broad phonetic transcription. Each item correctly repeated was assigned one point.

Lexical skills. The '*Lexique en réception*' (Receptive Lexicon), a subtest from the standardized *Evaluation du Langage Oral* (Oral Language Evaluation) battery (ELO, Khomsi, 2001), was used to assess word comprehension. Children were shown four pictures and were asked to point to the one corresponding to the word pronounced by the examiner (20 items). The '*Lexique en production*' (Productive Lexicon) subtest from the same battery was used to assess word production. This task required children to name 50 pictures. For both subtests, one point was assigned for each correct answer.

Morphosyntactic skills. The 'Comprehension' subtest from the same battery was used to assess sentence comprehension. Children had to identify one of four pictures from the spoken description given by the examiner (32 sentences). Expressive skills were assessed using the same battery. Children had to complete 25 sentences elicited by the examiner, on the basis of pictures (e.g., Examiner: "There is one *man*, there are two…"; Child: "*men*"). For both subtests, one point was assigned for each correct answer.

Sentence repetition task. According to their age, children had to repeat between 9 and 15 sentences successively (L2MA-2 battery). Sentences were presented via a laptop and headset. The examiner noted down the children's answers as they were provided, recorded them on a digital dictaphone, then checked by listening to them once again before noting down the score. The scores were based on the total numbers of words correctly repeated.

2.2.1.2. Reading-related measures. Phonemic awareness. Phonemic awareness was assessed using the first phoneme deletion subtest from the EVALEC battery. Stimuli were 12 tri-phonemic pseudowords, with a consonant-consonant-vowel structure. The scores corresponded to the number of correct answers.

Rapid automatized naming. Rapid naming was assessed through the '*Dénomination RApide Enfants*' (Rapid Automatized Naming, RAN) test for children (DRA Enfants, Plaza & Robert-Jahier, 2006). Children were required to name 12 series of four pictures corresponding to familiar monosyllabic words: *verre* (glass), *lit* (bed), *cœur* (heart), and *chien* (dog). Answers were recorded on a digital dictaphone, then listened to again before the scores were noted. The score corresponded to the numbers of pictures correctly named per second.

Knowledge of letters. We used a designation task to assess how well the following 15 letters were known: b, c, d, g, h, j, k, m, n, q, s, w, x, y, z. To prevent a ceiling effect and to increase the sensitivity of the task, the letters selected were of low to medium frequencies, according to the Lexical Database for French (New, Pallier, Ferrand, & Matos, 2001). Moreover, the letters selected were those that are likely to cause confusion (e.g., b/d) in order to heighten the distinction between children with and without a written language disorder. Each correct answer was assigned one point.

2.2.2. Reading skills

2.2.2.1. Text reading. The Alouette French reading test (Lefavrais, 1967) was used to assess text reading. This is the most frequently used test in France, in both clinical and research settings (Bertrand, Fluss, Billard, & Ziegler, 2010; Olivier, 2007). The final score takes both accuracy and speed into account, and provides a reading age.

This test was scored in two different ways. The first was subjective and followed the handbook instructions: A mistake likely to be caused by an expressive phonological disorder was not counted as a reading error. For example, the word '*bois*' (wood) read /pwa/ was considered as correctly produced by the child with 2SLI if he/she frequently pronounced /p/ instead of /b/ when he spoke. The second scoring was objective: All errors were taken into account.

2.2.2.2. Single-word reading. The EVALEC computerized battery (Sprenger-Charolles et al., 2005, 2010) was used to analyze word reading procedures. Three subtests were given:

1. '*LevOrt*' (orthographic complexity level) includes 36 regular words and 12 irregular words, matched for the number of letters, phonemes, and syllables and for the frequency of bigrams[2] and the words. This subtest assesses the orthographic reading procedure by analyzing the regularity effect.
2. '*LexOrt*' (lexicality and orthographic complexity) includes 36 regular words (from the LevOrt subtest) and 36 pseudowords. Items are matched for the number of letters, phonemes, and syllables and for frequency of bigrams. This subtest assesses the phonological procedure by analyzing the lexicality effect.
3. '*LexLength*' (lexicality and length) includes 10 short and 10 long pseudowords. This subtest assesses the phonological procedure, by analyzing the pseudoword-length effect. It also contains 20 irregular words to assess the orthographic procedure.

For these three subtests, both accuracy and latencies were recorded.

While the child was taking the test, the examiner gave him/her a preliminary score based on the accuracy of the answers. After the session, the examiner listened again to the answers recorded on the EVALEC software, to check the accuracy score and provide the latency scores. Both scores were calculated according to the handbook instructions. A mistake attributed to a phonological disorder was counted as a reading error. The accuracy and latency scores were expressed as percentages of correct answers and as milliseconds, respectively.

[2] A bigram is a sequence of two letters (Balota et al., 2007),

2.3. Procedure

Each child was assessed in a quiet room during three individual sessions lasting 30–45 min each. During the first session, the children did the spoken lexical and morphosyntactic skill subtests (ELO) as well as the word and pseudoword repetition task. During the second session, four specific skills were assessed: reading aloud single words and phonemic awareness (EVALEC), reading text (Alouette), letter knowledge, and nonverbal intellectual skills. At the third session, their skills in sentence- and pseudoword-repetition tasks (L2MA-2) and rapid automatized naming (DRA Enfants) were assessed.

2.4. Reliability

Intra- and inter-rater reliabilities were both assessed for single-word reading (EVALEC). This was carried out on 7.41% of the data and based on four randomly selected children, two from the 2SLI group and two from the control group. Intra-rater variability was evaluated by comparing the percentage of identical results between the first and second scorings. There were 98.66% of identical results for accuracy of the children's answers and 99.89% for latencies. Inter-rater variability was assessed using a score determined by an experienced speech-therapist working with children with SLI. Both raters provided 97.82% of identical scores for accuracy and 98.31% for latencies.

3. Results

3.1. Reading aloud

As previously mentioned, our primary aim was to conduct an in-depth investigation of reading aloud in children with 2SLI.

3.1.1. Reading level

The first objective was to accurately quantify reading levels in these children.

The 2SLI group was compared with a control group matched for regular-word reading accuracy and latency scores (EVALEC). The average chronological age of the 2SLI group was 10.95 (range: 7.70–12.90) and that of the RL-matched control group was 7.84 (range: 6.25–11.48); this 3.11 year average difference was shown to be significant, $t(52) = 9.13$, $p < .001$.

Based on the Alouette test standards, the subjective and objective scorings of text reading skills in children with 2SLI showed an average delay of 3.41 (range: 0.74–5.15) and 3.54 (range: 0.78–5.31) years, respectively. Irrespective of the kind of scoring, 22 out of 27 children with 2SLI (approx. 80%) had a reading delay of more than 24 months. Two children (approx. 10%) showed a delay between 18 and 24 months, and three (approx. 10%), a delay less than 18 months. Most children with 2SLI can therefore be said to be affected by a reading-aloud disorder.

3.1.2. Word reading procedures

Our second aim was to analyze word reading procedures, within the dual-route framework via a group comparison analysis (2SLI vs. RL-matched control children). For this purpose, accuracy and latency scores of single words and pseudowords (EVALEC) in both groups were computed, as shown in Table 1.

Latencies in excess of 4250 ms were removed (0.68% in the 2SLI group, 3.64% in the RL-matched control group), because at this level, the latency distribution curve tends toward zero. For the purpose of reliability, mean latencies were considered

Table 1
Accuracy and latency scores of single words and pseudowords (EVALEC) in children with specific speech and language impairment (2SLI) and control children.

Reading (EVALEC)	Measure		Children with 2SLI	Control children
Regular words (LevOrt or LexOrt subtests)	Accuracy (% corr.)	Mean (SD)	77.37 (13.99)	77.78 (20.82)
		Range	50–97.22	13.89–100
	Latencies (ms)	Mean (SD)	1078 (378)	1182 (573)
		Range	628–2049	602–2756
Pseudowords (LexOrt subtest)	Accuracy (% corr.)	Mean (SD)	52.37 (23.89)	60.60 (20.38)
		Range	11.11–88.89	16.67–88.89
	Latencies (ms)	Mean (SD)	1351 (487)	1388 (569)
		Range	812–2573	633–3420
Short pseudowords (LexLength subtest)	Accuracy (% corr.)	Mean (SD)	65.56 (24.55)	70.37 (21.57)
		Range	10–100	10–100
Long pseudowords (LexLength subtest)	Accuracy (% corr.)	Mean (SD)	38.89 (23.91)	47.04 (29.20)
		Range	0–80	0–100
Irregular words (LevOrt subtest)	Accuracy (% corr.)	Mean (SD)	61.42 (27.75)	58.64 (26.10)
		Range	0–100	0–91.67

only when there were at least five correct answers per item category. In these conditions, only the lexicality effect (regular words vs. pseudowords) could be assessed. It was computed from a total of 26 instead of 27 children per group, because the performances of one child from the 2SLI group and one from the control group had to be excluded from the analyses due to poor accuracy.

Mean correct answer percentages and mean latencies were calculated across items for the by-participant analysis (F_1) and across participants for the by-item analysis (F_2). Data on the different reading effects regarding lexicality, length of pseudowords, and regularity were analyzed with a set of 2 (*Group*: 2SLI vs. RL-matched control) × 2 (Type of Item) repeated measures analysis of variance (ANOVA). *Group* was treated as a *between factor* in the by-participant analyses and as a *within factor* in the by-item analyses. *Type of item* was treated as a *within factor* in the by-participant analyses and as a *between factor* in the by-item analyses.

3.1.2.1. Lexicality effect. The children's reading performance was analyzed with a 2 (*Group*: 2SLI vs. RL-matched control) × 2 (*Lexicality*: regular words vs. pseudowords LexOrt) repeated measures ANOVA.

Accuracy. There was no effect of *group* in the by-participant analysis ($F_1 < 1$) although it was significant in the by-item analysis, $F_2(1,70) = 9.32$, $p = .003$, $\eta_p^2 = .12$, where RL-matched control children showed higher performance. There was a main effect of *lexicality*, $F_1(1,52) = 144.52$, $p < .001$, $\eta_p^2 = .73$, $F_2(1,70) = 38.83$, $p < .001$, $\eta_p^2 = .36$, indicating that regular words were read more successfully than pseudowords (correct answers for regular words: 77.57%, pseudowords: 56.48%). The interaction between *group* and *lexicality* was significant, $F_1(1,52) = 4.97$, $p = .03$, $\eta_p^2 = .087$, $F_2(1,70) = 7.63$, $p = .007$, $\eta_p^2 = .098$, with the lexicality effect being greater in children with 2SLI than in RL-matched control children.

Latencies. The groups did not differ (F_1 and $F_2 < 1$). There was a main effect of *lexicality*, $F_1(1,50) = 27.30$, $p < .001$, $\eta_p^2 = .35$, $F_2(1,70) = 35.34$, $p < .001$, $\eta_p^2 = .33$, indicating that regular words were read more quickly than pseudowords (regular words: 1130 ms, pseudowords: 1370 ms). The interaction between *group* and *lexicality* was not significant (F_1 and $F_2 < 1$).

3.1.2.2. Length effect on pseudowords. Children's reading performance was analyzed with a 2 (*Group*: 2SLI vs. control) x 2 (*Length*: short pseudowords vs. long pseudowords, LexLength) repeated measures ANOVA. Again, there were discrepancies with regard to the *group* effect, which was significant in the item analysis only, $F_1(1,52) = 1.10$, $p = .30$, $\eta_p^2 = .02$, $F_2(1,18) = 5.47$, $p = .031$, $\eta_p^2 = .23$. There was a main effect of *length*, $F_1(1,52) = 79.77$, $p < .001$, $\eta_p^2 = .60$, $F_2(1,18) = 16.61$, $p = .001$, $\eta_p^2 = .48$, indicating that short pseudowords are read more successfully than long pseudowords (correct answers for short pseudowords: 67.96%, long pseudowords: 42.96%). The interaction between *group* and *length* was not significant (F_1 and $F_2 < 1$).

As mentioned above, effects on response latencies were not examined, given the small number of correctly read items.

3.1.2.3. Regularity effect. The children's reading performance was analyzed using a 2 (*Group*: 2SLI vs. control) × 2 (*Regularity*: regular vs. irregular words) repeated measures ANOVA. Groups did not differ (F_1 and $F_2 < 1$). There was a main effect of *regularity*, $F_1(1,52) = 52.04$, $p < .001$, $\eta_p^2 = .50$, $F_2(1,46) = 14.31$, $p < .001$, $\eta_p^2 = .24$, indicating that regular words are read more successfully than irregular words (correct answers for regular words: 77.57%, irregular words: 60.03%). The interaction between *group* and *regularity* was not significant (F_1 and $F_2 < 1$).

3.1.3. Subtyping reading disorders

Lastly, interindividual differences were assessed through multiple case analyses, in order to establish reading-disorder subtypes.

Subtyping of each child with 2SLI was derived from pseudoword and irregular word reading accuracy scores only (EVALEC). Indeed, as mentioned above, for the purpose of reliability, mean latencies were considered only when there were at least five correct answers per item category. Pseudoword-latency scores but not irregular-word scores could then be assessed.

To compute pseudoword and irregular-word identification accuracy scores, we calculated an average standard score based on two subtests, in order to gather a maximum number of items (LexOrt and LexLong for pseudowords, NivOrt and LexLong for irregular words). These scores were individually compared to EVALEC standards corresponding to the children's reading age, which was determined using the Alouette reading task. For example, one child with 2SLI (age 12.08) had an Alouette reading age of 8.25. His three scores for LexOrt and LexLong (short and long) pseudowords were compared to EVALEC standards for children aged between 7.50 and 8.42. The mean of these three *z* scores was the average *z* score of pseudoword reading accuracy. Similarly, performance on NivOrt and LexLong (short and long irregular words) subtests were used to compute an average *z* score of irregular-word reading accuracy.

A child was considered as presenting a phonological profile if his/her pseudoword accuracy score fell below the cut-off point (−1.65 SD), while the irregular-word accuracy score came above the cut-off. A child was considered as presenting a surface profile when reading scores were below the cut-off on irregular words and above the cut-off on pseudowords. A child with both reading scores within the norm was said to have a delayed, nondissociated profile. Six of the 27 children with 2SLI had a phonological reading disorder (phonological subgroup, about 20%), two presented a surface reading disorder (surface subgroup, approx. 10%), and 16 children showed a delayed reading profile (delayed subgroup, approx. 60%). Lastly, three children had reading skills within normal limits (normal subgroup, approx. 10%, see Section 3.1.1).

3.2. Relationship between spoken language and reading aloud

Our second aim was to examine how spoken language (including general and reading-related skills) is related to reading aloud in children with 2SLI.

3.2.1. Group comparisons: children with 2SLI versus RL-matched control children

Spoken language characteristics of both groups are summarized in Table 2.

With regard to general measures of spoken language, children with 2SLI performed less well than RL-matched control children on the following four tasks: pseudoword repetition, $t(52) = 5.64$, $p < .001$, word repetition (our specially created task), $t(52) = 4.79$, $p < .001$, sentence completion (ELO), $t(52) = 2.92$, $p = .005$, and sentence repetition (L2MA-2), $t(52) = 8.35$, $p < .001$. A nonsignificant trend toward a difference on the word comprehension task (ELO), $t(52) = 1.94$, $p = .058$, was also observed. There were no differences between the two groups with regard to word production (ELO), $t(52) = 1.06$, $p = .29$, and sentence comprehension (ELO), $t(52) < 1$, *ns*.

Concerning reading-related skills, the scores in phonemic awareness, $t(52) = 1.01$, $p = .32$, and letter knowledge, $t(52) < 1$, *ns*, were similar in both groups. There was however, a nonsignificant trend in rapid naming scores in favor of children with 2SLI, $t(52) = 1.94$, $p = .057$.

3.2.2. Comparisons between reading disorder subtypes

The Mann–Whitney test was used to determine relationships between spoken language skills and reading profiles of children with 2SLI in the two largest subgroups, namely the delayed and phonological groups. The scores of the latter were found to be significantly lower than those of the former on the following tasks: pseudoword repetition ($U = 21$, $p = .044$), word and pseudoword repetition with our specially created task ($U = 20$, $p = .039$), and letter knowledge ($U = 21$, $p = .011$). Lastly, a marginally significant difference was noted with the phonological subgroup performing less well than the delayed subgroup on the following tasks: word repetition with our specially created task ($U = 24.5$, $p = .081$) and sentence completion ($U = 25$, $p = .088$).

Table 2
Spoken language characteristics of children with specific speech and language impairment (2SLI) and control children, including general and reading-related measures.

Test	Measure	Children with 2SLI	Control children
Simple pseudoword repetition (L2MA-2, /10)	Mean (SD)	2.48 (2.24)	7.74 (1.81)
	Range	0–6	4–10
Complex pseudoword repetition (L2MA-2, /10)	Mean (SD)	1.70 (0.99)	3.63(1.28)
	Range	0–4	1–6
Pseudoword repetition (specially created task, /20)	Mean (SD)	6.48 (2.87)	11.41 (3.51)
	Range	1–14	5–16
Word repetition (specially created task, /20)	Mean (SD)	11 (3.91)	15.15 (2.21)
	Range	3–20	10–19
Word comprehension (ELO, /20)	Mean (SD)	16.19 (1.57)	17.04 (1.65)
	Range	12–19	13–20
Word production (ELO, /50)	Mean (SD)	28.48 (4.29)	30.07 (6.54)
	Range	21–36	18–42
Sentence comprehension (ELO, /32)	Mean (SD)	22.04 (5.47)	20.93 (3.58)
	Range	9–29	15–28
Sentence completion (ELO, /25)	Mean (SD)	14.48 (4.80)	17.74 (3.27)
	Range	2–21	12–23
Sentence repetition (L2MA-2, /98)	Mean (SD)	60.67 (11.86)	84.93 (9.35)
	Range	31–76	55–96
Phonemic awareness (Phoneme deletion subtest, EVALEC, % corr.)	Mean (SD)	45.99 (23.38)	52.78 (25.94)
	Range	0–83.33	0–100
Rapid automatized naming (DRA Enfants, number of pictures corr. named/s)	Mean (SD)	1.09 (0.26)	0.96 (0.19)
	Range	0.57–1.67	0.71–1.39
Letter knowledge (specially created task, /15)	Mean (SD)	14.19 (1.44)	14.37 (0.97)
	Range	9–15	12–15

4. Discussion

4.1. Discussion of results

4.1.1. First aim: to conduct an in-depth investigation of reading aloud in children with 2SLI

4.1.1.1. Reading level. As a group, children with 2SLI have an average reading delay of 3.1 years with regard to regular-word reading. For text reading, the average delay is 3.5 years. These results can be considered as a severe reading impairment. They are consistent with the existing literature on children with SLI (mentioned in Section 1.4), which reports a deficit in reading aloud of words. Nevertheless, our results cannot be compared directly with those of previous studies for three reasons. Firstly, there are very few studies on children with 2SLI: Most research relates to children with SLI, without specifying whether some have 2SLI, and if so, how many. Secondly, SLI and control groups have never been matched according to reading level but rather according to age or spoken language level. Thirdly, reading measures are usually assessed in terms of *z* scores, weak percentiles, or statistically significant differences, but not in terms of years of delay. To our knowledge, only one study, namely that of Haynes and Naidoo (1991), has investigated this question; these authors showed an average reading delay of three years for a group of 118 children with SLI, average age 11.5 years. Our results are therefore clearly in line with their observations.

As individuals, most children with 2SLI are affected by a deficit in reading-aloud skills, because approx. 80% exhibit a severe (in excess of 24 months) and about 10% a moderate (between 18 and 24 months) reading delay. However, some children (approx. 10%) do perform within normal limits (delay less than 18 months). This last proportion is quite unexpected given the phonological-production impairment observed in all our children with 2SLI. Indeed, this is commonly viewed as generating a word reading deficit. Nevertheless, this unexpected success in reading has already been highlighted in some studies (Bishop et al., 2009; Vandewalle, Boets, Ghesquière, & Zink, 2010; Vandewalle, Boets, Ghesquière, & Zink, 2012). According to these authors, one explanation could be the spared rapid automatized naming skills.

4.1.1.2. Word reading procedures. The lexicality effect on accuracy scores was stronger in children with 2SLI than in RL-matched control children. This result supports the idea of a specific deficit of the phonological procedure. For latencies, the lexicality effect was similar in both groups. In other words, although children with 2SLI frequently answered incorrectly, they nevertheless answered quickly. The length effects on pseudowords were also similar in both groups. The regularity effects did not differ, indicating equivalent effectiveness of the orthographic procedure. With reference to the dual-route model, because the phonological procedure was more severely affected than the orthographic procedure, children with 2SLI, as a group, can be viewed as presenting a word reading deviance and not merely a delay.

The present study cannot be easily compared to others; it does however, have similarities with the work of Bishop and Clarkson (2003), who compared children suffering from SLI with younger ones of a similar vocabulary level. These authors showed that children with SLI make more phonological spelling errors than the control children, but not more orthographically illegal errors. This suggests that the phonological procedure is more severely affected than the orthographic procedure. Our results are in line with this conclusion.

4.1.1.3. Subtyping reading disorders. Reading disorders in children with 2SLI can be classified into four subgroups: phonological (with approx. 20% of children), surface (approx. 10%), delayed (approx. 60%), and normal (approx. 10%) profiles. Interindividual heterogeneity is therefore high with four different subtypes of reading profiles.

While group analyses have shown a specific deficit of the phonological procedure, multiple case analyses have revealed that only 20% of children display a phonological profile. This apparent mismatch is similar to a result found in dyslexic children (25%–39% of phonological profiles, Sprenger-Charolles et al., 2011). Such a discrepancy may indicate that most children with 2SLI have a deficit, albeit mild, in pseudoword reading. It may also be partly due to the item category in question. While lexicality effects in group comparison analyses are measured by comparing pseudowords to regular words – all other sublexical properties being constant – multiple case analyses have a different objective; in the search for double dissociations, pseudowords, which serve as indications for assessing the orthographic procedure, are contrasted with irregular words, which are used to assess the orthographic procedure.

4.1.2. Second aim: connecting reading aloud to language skills

4.1.2.1. Group comparisons: 2SLI versus RL-matched control children. Matching groups on the reading level should yield similar levels of achievement in repetition tasks. Although our matching was done this way, children with 2SLI actually exhibited significantly lower scores than control children in word- and pseudoword-repetition tasks. This suggests that children with SLI have developed reading skills with underachievement in the phonological processing area, a pattern which is compatible with the frequently reported phonological deficit in SLI (Leonard, 1998).

The scores of children with 2SLI are also poorer for the tasks of completing and repeating sentences, which call upon morphosyntactic production abilities. This result can be explained in two ways. Firstly, some authors assume that a phonological deficit generates morphosyntactic impairments in children with SLI (see the review by Parisse & Maillart, 2008). Secondly, this result supports the notion that children with SLI have considerable difficulties in the morphosyntactic area: They have already been identified as weak in this area, even compared with younger children with the same spoken-language level (Leonard, 1998).

The phonological and morphosyntactic production of children with 2SLI tends to be lower than that of RL-matched control children. Hence, their reading abilities are better than might be expected based on the two oral skills mentioned. In other words, children with 2SLI reach the same reading level as control children, despite their deficit in these two spoken-language areas. This suggests that their impairment hinders reading development to a lesser degree than it does spoken-language development.

4.1.2.2. Comparisons between reading disorder subtypes. Phonological skills. We observed a significant difference in word and pseudoword repetition tasks, with lower performance in the phonological subgroup. This confirms the link between spoken language and reading deficits, which is in line with several studies showing that a severe expressive phonological disorder observed in children with SLI before they learn to read, predicts a weakness in identifying written words and pseudowords once they have been taught to read (Bird, Bishop, & Freeman, 1995; Larrivee & Catts, 1999).

Letter knowledge. There is also a deficit in the phonological subgroup for letter knowledge. There is now a well-established, strong link between written-word identification skills and letter knowledge, the latter representing the best kindergarten predictor of word- and pseudoword reading skills, two and four years later (Catts et al., 2002).

Morphosyntactic production. We observed a trend toward a deficit in the phonological subgroup with regard to the sentence-completion task. This is in line with the findings of several longitudinal studies showing that morphosyntactic production skills in children with SLI in kindergarten are predictive of their abilities to identify written words and pseudowords after they have been reading for a year or more (Bishop & Adams, 1990; Catts et al., 2002).

4.2. Suggestions for further studies

Following on from our observations, the four key points below suggest novel lines of thought for future research.

4.2.1. Impact of lexico-semantic capacities upon written word identification

It may well be useful to investigate the link between lexico-semantic skills and written-word identification skills in children with 2SLI (or even SLI), which we did not consider here. A deficit in this area has already been shown likely to influence the mechanisms for written-word identification in poor comprehenders (Nation & Snowling, 1998b; Ricketts, Nation, & Bishop, 2007) and in dyslexic children (Nation & Snowling, 1998a). We could hypothesize that the same may occur in children with 2SLI (or even SLI). To test this assumption, one could compare the reading performance of two groups of children with 2SLI (or even SLI) with the same reading-aloud level, the first showing lexico-semantic impairment, the second, not.

4.2.2. Measurement of phonological processing

Some authors have highlighted the need to make a distinction between several components of phonological processing, in order to understand the role of phonology in spoken language and reading acquisition. Ramus, Marshall, Rosen, and van der Lely (2013) found that phonological representations, such as speech discrimination, repetition of simple, short pseudowords, may be important for the development of spoken language, whereas phonological skills (e.g., phonological awareness, rapid automatized naming, or short-term memory, such as the forward digit-span) appear to be more important for written-language acquisition. However, the multisyllabic word and pseudoword repetition task used in the present study draws on both phonological representations and phonological skills. Therefore, to accurately relate phonological-processing system abilities to written- or spoken-language skills would require this repetition score measurement to be combined with others, relating in particular to the phonological representations.

4.2.3. Comparing the profiles of children with 2SLI (or even SLI) and dyslexic children

Our study only included children with 2SLI. To further investigate the relationships between 2SLI (or even SLI) and reading disorders, it may well be useful to compare the achievements of children with 2SLI (or even SLI) and those of dyslexic children on word- and pseudoword reading, with reference to the dual-route model.

4.2.4. Assessing reading skills with other methods

In the present work we assessed children's reading skills by measuring accuracy and latency in reading-aloud tasks. Other methods could be used, such as analyzing the nature of children's mistakes. Indeed, it is widely accepted that if a child lexicalizes pseudowords or regularizes irregular words, it is because either his phonological procedure or his orthographic procedure, respectively, is impaired. Another approach could be to use tasks requiring the child to provide nonspoken answers, such as lexicon decisions regarding written items. This would avoid classifying as a reading mistake, a speech production error due to a potential deficit that is likely to affect the motor output program of speech in children with SLI (Hill, 2001; Rechetnikov & Maitra, 2009; Visscher, Houwen, Scherder, Moolenaar, & Hartman, 2007). Lastly, a longitudinal investigation of the stability over time of the reading profiles of children with 2SLI (or even SLI) would certainly provide interesting findings.

4.2.5. Using reading to develop spoken language in children with 2SLI (or even SLI)

The fact that children with 2SLI reach the same reading level as control children, despite their deficit in phonological and morphosyntactic production suggests that reading development may be less hindered by 2SLI than spoken language development. It may therefore be easier for children with 2SLI to improve their reading skills than their spoken-language skills.

From a clinical standpoint, this leads us to speculate whether reading could be used as a means to develop spoken language, at least in certain areas. Indeed, certain data reported in the literature show that orthographic knowledge has an effect on spoken abilities in typically developing children (Ventura, Morais, & Kolinsky, 2007). The Matthew effect on vocabulary suggests in particular that children with a better reading achievement during the first years of learning, improve their vocabulary to the greatest extent after several years of reading experience (Cain & Oakhill, 2011; Kempe, Eriksson-Gustavsson, & Samuelsson, 2011). Similarly, according to Ricketts, Bishop and Nation (2009), an incidental exposure to orthography facilitates spoken-vocabulary learning for children aged 8–9 years, which supports the hypothesis of a positive effect of reading on spoken language. Two longitudinal studies on children with SLI (Bishop et al., 2009; Conti-Ramsden & Durkin, 2007) have also shown a decisive influence of reading skills on their ability to repeat pseudowords, a few years later. Further research into the influence of reading on the spoken performance of children with 2SLI (and of course, SLI) would therefore be particularly valuable.

4.3. Implications for clinical practice

Our results show that in children with 2SLI, both the phonological and the orthographic reading procedures are impaired. Thus, in therapeutic settings, both procedures should be exercised, with emphasis on the phonological reading procedure for children with more severe deficits in phonological production.

5. Conclusion

This study explored the reading skills of single words in 27 French children with specific speech and language impairment (2SLI). Precise quantification of reading levels in the 2SLI group showed an average delay of 3.5 years. Approximately 90% of these children were affected by a reading disorder, whereas for the remaining 10%, reading performance was within normal limits. Word reading procedures were analyzed using the so-called 'dual route model', which proposes that reading is achieved through two procedures, the nonlexical phonological procedure and the lexical orthographic procedure. Group comparison analyses, including 27 reading level-matched control children, revealed an increased lexicality effect in the 2SLI group, indicating a specific deficit in the phonological procedure. Moreover, multiple case analyses revealed interindividual differences among the children with 2SLI, with four reading subtypes. Approximately 60% of these children presented a delayed reading profile, that is, they achieved the standard levels expected of younger children with identical reading levels, in both procedures.

Twenty percent showed a phonological profile, that is, qualitatively different reading mechanisms, with a greater deficit in the phonological procedure. These children had a severe impairment in language production at the phonological level. Ten percent had a surface profile, that is, a greater orthographic deficit, and a further 10%, a normal profile, with normal reading skills. Further research areas are suggested to improve our understanding of reading skills in children with 2SLI (or even SLI). In clinical practice, the present results suggest that both reading procedures should be exercised, with emphasis on the phonological procedure for children with more severe deficits in phonological production.

Acknowledgments

This study was made possible by a Nord-Pas de Calais Regional grant award to LM. The authors would like to thank the children, their parents, the healthcare professionals and school staff, and in particular, the Linselles CMP and SESSD, the Arras SESSAD, and the Liévin and Longuenesse CLIS-SESSAD. They express their gratitude to Dr. Françoise Boidein for engaging discussions in a supportive environment, Marie Compagnon and Laurie Dupé for help in data collection, to Séverine Buhan and Christel Dubus whose network facilitated the participant enrolment, to Christelle Damoy for inter-rater assessments, and to Moyra Barbier for editorial assistance.

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