Chapter 5

Sensitivity to subject-verb agreement, phonological processing and literacy skills in children with language impairments

5.1 Introduction

The previous chapter showed that poorly reading children were less good in detecting agreement violations at kindergarten age compared with control children. This chapter focuses on subject-verb agreement in older children with developmental dyslexia and elaborates on the relationships between morphosyntax, various forms of phonological processing and word recognition and decoding.

In this chapter two studies will be presented. The first one investigates whether dyslexic children are as sensitive to subject-verb agreement as normally reading children are\(^1\). As it will be shown, that is not the case and therefore a second study has been conducted that further investigates the extent and origin of the decreased sensitivity to subject-verb agreement in dyslexia. In the latter study, the performance of the dyslexic children is furthermore compared with that of children with SLI to explore possible commonalities between the two types of developmental language disorders.

5.2 Study 1

5.2.1 Introduction

Several researchers have explained dyslexia as the result of a core deficit in phonological processing (see Rack (1994) for an overview). Apart from impaired performance on tasks tapping phonological skills, weaknesses in other linguistic modules have been demonstrated. Children with dyslexia have been found to have poorer expressive vocabulary (Swan & Goswami, 1997), poorer understanding of syntactically complex sentences (Bar-Shalom et al., 1993; Byrne, 1981; Crain & Shankweiler, 1990; Mann et al.,

\(^1\) Parts of this study have been presented in Rispens et al. (2004; in press).
1984; Stein et al., 1984), poorer comprehension of pronouns in certain sentence contexts (Waltzman & Cairns, 2000) and to have more problems with the formation of the past tense (Joanisse et al., 2000) than normally developing children (for a more detailed review, see chapter 2).

The syntactic relation between a subject and a verb has not been investigated as yet in dyslexia. Information on different types of language behaviour is needed to form a complete linguistic typology of dyslexic children, and a main aim of this first study is therefore to assess sensitivity to subject-verb agreement morphology.

In the following experiment, subject-verb agreement morphology will be investigated using a grammaticality judgement task and by analysing the ability to mark verbs correctly for agreement in spontaneous speech. Children with developmental dyslexia will not only be compared with normally reading children of their own age, but also with younger children who have the same reading level as the dyslexic children. The inclusion of such a control group has the advantage that this provides insight into the possibility that an observed difference between dyslexic children and children without dyslexia, who are matched on age, stems from the delay that the dyslexic children have with respect to reading experience and exposure to written text. Access to print and high level written language may have a positive effect on language development. Not only may new words be encountered in this way, but also infrequently used sentence structures in spoken language situations (for instance, the passive construction). Furthermore, reading language in addition to hearing language may raise awareness to certain linguistic features, which may include subject-verb agreement. Thus, it could well be that a possibly observed impairment in the sensitivity to subject-verb agreement follows from the consequence of the reading impairment (less access and exposure to print) rather than that this observed impairment may somehow be related to the deficit that causes the impairment in reading and spelling.

Comparing dyslexic children with children who are matched on reading level in addition to children matched on age will provide more information about the direction of the relationship between reading impairment and grammatical impairment (Bryant, 1995). If the dyslexic children do not only perform more poorly than normally reading children matched on chronological age, but also more poorly than children matched on their reading level, it cannot be the case that the lag in reading experience is the major cause of the grammatical deficit. Based on the data of the previous chapter, it is not expected that any observed decreased sensitivity to agreement in dyslexic children is the result of a lag in reading experience compared to non-dyslexic children, as at pre-reading age there was
already a difference in sensitivity to agreement between children who had problems with reading acquisition and those who did not. However, since there are no data available on the sensitivity to subject-verb agreement in this group of participants, this possible source of language difficulty needs to be investigated.

5.2.2 Research questions

The following questions will be addressed in Study 1:

(1) Are children with developmental dyslexia as sensitive to subject-verb agreement morphology as normally developing children?

(2) If this is not the case, is decreased sensitivity to agreement morphology a consequence of a lag in reading experience?

5.2.3 Method

5.2.3.1 Subjects

Children with developmental dyslexia

Twenty-six Dutch children with developmental dyslexia (16 boys, 10 girls, mean age 8;09 years) participated in this study. The children of the experimental group were either diagnosed with developmental dyslexia by educational specialists or were in the process of being formally diagnosed. They were selected for this study on the basis of their reading level measured by a standardised test (AVI (Van den Berg, 1991\(^2\))) used in schools to monitor reading progress. The AVI-scores of these children indicated a delay of at least one and a half years compared with the reading level expected based on age and school grade. In the Dutch school system, children enter primary school when they are four years old. The first two years correspond to kindergarten, after which they enter group

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\(^2\) AVI (Analysis of Individualisation Form) is a reading test consisting of nine reading charts, each containing a text. Each chart corresponds to a level of technical reading ability. The test measures both accuracy and speed of reading.
three, the first year that they start with formal reading instruction. Generally speaking, children in the Netherlands are six years old when they start to learn to read.

All but one of the children attended main-stream primary schools. (Non)-verbal intelligence of 14 children was formally assessed by educational specialists as part of the diagnostic procedure. Children who had not (yet) been assessed (12 of the 26 children) were presented with the task ‘figures’\(^3\) (non-verbal task), ‘similarities’\(^4\) and ‘vocabulary’ (verbal tasks) of the Dutch version of the intelligence test battery WISC-R (Van Haasen et al., 1986). Scores below 7 indicate poor performance, between 7-13 average performance and above 13 above-average performance. All children scored between 9 and 19 on the three tasks (mean score figures: 11, similarities: 13, vocabulary: 11), demonstrating at least average performance and indicating that all children had normal IQs.

None of the children had a history of speech and language therapy, nor were they currently enrolled in a speech and language training program. Some of the children received remedial teaching, specifically focused on their reading and or spelling problems.

**Chronological Age control group (CA control group)**

The chronological age control group consisted of 26 Dutch children (16 boys, 10 girls, mean age 8;11) with at least average reading skills as assessed by the AVI test. Only children who demonstrated normal progress in school were included.

**Reading Age control group (RA control group)**

A second control group consisted of 9 children (5 boys, 4 girls, mean age 7;01) who were matched on the AVI-scores of the dyslexic children. All children attended group 3 of a Dutch primary main-stream school. The children were tested at the end of the school year, having received almost a year of reading instruction. The AVI-levels of the RA control group were the ones expected for their age. Only children who demonstrated normal progress in school were included.

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\(^3\) In this task children are presented with pieces of a jig saw puzzle and are asked to solve the puzzle (make a figure) as fast as possible. The score depends on the accuracy and on the time the children need to accomplish the task.

\(^4\) In the task ‘similarities’, children are presented with two concepts and are asked to explain why these concepts are related to each other (for instance ‘marble’- ‘ball’ and ‘meter’ - ‘kilo’).
Table 1 gives an overview of the background of the three subject groups. A one-way ANOVA (post-hoc tests Scheffé when variances were equal, Games-Howell for unequal variances) revealed no difference between the dyslexic and the chronologically age-matched control children (CA control children) in the factor age (p=0.8), but their AVI-levels were significantly different (p<0.001). The reading-age matched children (RA control children) were significantly younger (mean difference: 1 year and 8 months) than the dyslexic children (p<0.001), but had the same AVI-level (p=0.3). The CA control children were significantly older than the RA control children (mean difference 1 year and 10 months) and had significantly higher AVI-levels (both measures, p<0.001).

Table 1. An overview of the mean age and AVI-levels and the standard deviations (SD) of the three subject groups.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Dyslexic children N=26</th>
<th>CA control children N=26</th>
<th>RA control children N=9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in months</td>
<td>Mean 105, Range 92-124, SD 8</td>
<td>Mean 107, Range 96-121, SD 1</td>
<td>Mean 85, Range 74-92, SD 7</td>
</tr>
<tr>
<td>AVI</td>
<td>Mean 3.4, Range 1-5, SD 1.0</td>
<td>Mean 7.7, Range 6-9, SD 1.0</td>
<td>Mean 3.8, Range 3-4, SD 0.4</td>
</tr>
</tbody>
</table>

5.2.3.2 Materials

Reading tasks

Two standardised reading tasks were administered: the one-minute real-word reading test (RWT) of Brus & Voeten (1972) and the two-minute pseudo-word reading test (PWT) of Van den Bos et al. (1994). These tasks tap word recognition (reading aloud words) and word decoding skills (reading aloud pseudo-words).

The term ‘word recognition’ is used in this thesis to refer to the process that on visual perception of a word, it will be recognised, if its printed representation is stored, in for instance, a so-called ‘visual input lexicon’ as suggested by Ellis & Young (1988). In addition, the activation of the representation in the ‘visual input lexicon’ may activate the semantic representation of the word. In contrast, pseudo-words or existing words that somebody does not know, do not have a representation in the ‘visual input lexicon’. These words can only be decoded by converting graphemes into phonemes. This will result in a phonological representation, which can then be produced. Figure 1 is a visual representation of these reading processes, adapted from the model discussed in Ellis &
Young (1988). Measuring both word recognition and word decoding skills of the participants thus taps two different processes involved in reading.

The RWT and PWT have been standardised similar to the WISC-R, with a mean standard score of 10 and a standard deviation of 3. A standard score below 7 indicates poor performance (Van den Bos, 1998).

5 Note that only a part of the model of reading of Ellis & Young (1988) is addressed here.

Figure 1. A model of the recognition and decoding of (pseudo-) words, adapted from Ellis & Young (1988).

**Grammaticality judgement task**

The grammaticality judgement task has been introduced in chapter 4, but will be again explained here as there are some differences between the experimental set-ups. Sixty grammatical and ungrammatical sentences (subject-verb agreement violations and phrase-structure violations) were presented auditorily from a laptop computer (Toshiba Satellite).
The sentences of the subject-verb agreement condition consisted of a subject, a verb and an object or an adverbial phrase (see the examples below in type 1-3). Apart from sentences containing agreement violations, sentence with phrase-structure violations were presented. In these sentences a noun was missing from the Prepositional Phrase (PP); see type 4 for an example. This condition was added to see whether children were able to make meta-linguistic judgements, so that if judging sentences with agreement violations prove to be difficult, it can be estimated whether this is the result of a more general problem with making grammaticality judgements (as reflected by a poor score on the control condition).

For the subject-verb agreement condition, three types of ungrammatical variations on the Dutch inflectional paradigm were constructed:

**Type 1**. The verb was inflected for 1st person singular (also the verb stem) rather than the 3rd person singular:

*De leuke clown maak * een grapje versus * de leuke clown maakt een grapje

Lit. *the funny clown make [1st person sing./verb stem] a joke versus the funny clown makes a joke

**Type 2**. The verb was inflected for the plural form (also the infinitive) rather than the 3rd person singular:

*De leuke clown maken * een grapje vs * de leuke clown maakt een grapje

Lit. *the funny clown make [plural/infinitive] a joke versus the funny clown makes a joke

**Type 3**. The verb was inflected for the 3rd person singular rather than for the plural form:

*De leuke clowns maakt * een grapje vs * de leuke clowns maken een grapje

Lit. *the funny clowns makes [3rd person sing.] a joke versus the funny clowns make a joke

The control condition to investigate meta-linguistic judgement ability:

**Type 4**. Noun missing from a PP

*De jongen heeft in de gespeeld

Lit. *the boy has in the played
In total, the experiment consisted of 60 experimental sentences: 10 items were presented for each sentence type. Note that the grammatical sentences matching the type 1 and 2 subject-verb agreement violations are the same type of sentences (verb inflected for the third person singular) and are therefore taken together in the data analysis.

All lexical items in the sentences had been selected on the criterion that 6 year old children will have mastered them using the vocabulary list of Kohnstamm et al. (1981). The determiners of the nouns of the third sentence type were all de-words and all nouns were marked for plural with /s/. All words following the verb in the type 1 ungrammatical condition and all words, but one, following the verb in the type 1/2 grammatical sentences start with a phoneme other than a /t/ to prevent from co-articulation influences which would interfere with perception of the inflection morpheme; for example, *de jongen trap t tegen de boom* (the boy kicks against the tree), in which the /t/ of the verb *trap t* overlaps acoustically with the /t/ of the preposition *tegen*.

On average, the Noun Phrases in subject position that preceded the verb in the agreement conditions consisted of 5 syllables (range 3-7, SD 1). The number of syllables preceding the critical verb between the conditions was comparable (p >0.76). Across the trials, correct and incorrect sentences were pseudo-randomised and divided over two blocks. The order in which the blocks were presented was varied. The items are listed in Appendix I.

*Spontaneous speech analysis*

Spontaneous speech was elicited by a fixed set of questions in 10 children of the dyslexic group and 10 children of the CA group. The children were asked to tell something about their holiday, their family, their hobbies, their favourite television programme and their favourite subject in school.

Figure 2 gives an overview of the tasks used in Study 1.

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6 In Dutch, the lexical form of determiners of singular nouns is either *de* or *het*, depending on gender, but the determiner of plural nouns is always *de*. Nouns can be marked for plural by either the suffix –en or –s.
5.2.3.3 Procedure and data analysis

The reading tasks

The RWT (Brus & Voeten, 1972) and the PWT (Van den Bos et al., 1994) were administered in between the two parts of the grammaticality judgement task. The child was instructed to read aloud the words as fast as possible, but also as accurately as possible. The raw scores were computed by subtracting the number of words that were read incorrectly from the total number of words read. The raw scores were converted into standard scores. The RWT and PWT were only administered to the CA control children and the dyslexic participants, as these tests need to establish the difference in reading ability between the two groups. T-tests were used to compares such scores between the CA control children and the dyslexic children.

Grammaticality judgement task

The sentences were presented through headphones. A standardised introduction was presented to each child, explaining the idea behind the grammaticality judgement task. After that, an example block was started on the computer, containing three sentences (1 ungrammatical and 2 grammatical sentences) to practise the procedure. All example sentences were discussed to make sure the child understood the nature of the task. The child was instructed to press one of two keys of the laptop computer when s/he realised...
the sentence was good or bad. A sticker with a frowning face on one of the keys indicated an incorrect sentence, a sticker with a smiling face a correct sentence.

Responses were classified as correct or incorrect. The responses were differentiated for the four types of ungrammatical sentences (three types of subject-verb agreement violations, the incomplete PP condition) and the grammatical sentences matching the subject-verb agreement violations, as illustrated in Figure 3:

![Figure 3: the two conditions of the grammaticality judgement task.](image)

In addition, A' values were computed for the subject-verb agreement condition. This type of analysis adjusts the judgement scores for a possible bias of subjects to accept sentences rather than to reject them (cf. Linebarger, Schwartz & Saffran, 1983). The A’ values can be interpreted as scores on a two-alternative forced choice task: ‘which of these two sentences is grammatical?’ For example, an A’ value of 0.8 can be interpreted as a score of 80% correct when the child was asked to select one of two sentences on its grammaticality. Following Rice, Wexler & Redmond (1999) the formula as described in Linebarger et al. (1983) was used to calculate these scores: 

$$A' = 0.5 + \frac{(y-x)(1+y-x)}{4y(1-x)}$$

where y represents the correct judgements of grammatical sentences (‘hits’) and x the incorrect judgements of ungrammatical sentences (‘false alarms’). If a child has a strong tendency to reject sentences, the A' value will be approximately around 0. A tendency to accept sentences as grammatical will result in an A' value of around 0.5 and good discrimination between grammatical and ungrammatical sentences will result in an A' value of approximately 1.0 (top score).

To compare performance between the three groups, a one-way ANOVA was used. To determine significant differences between the groups post hoc, the Scheffé test was used. The Games-Howell test was used in the case of unequal variances between groups.
Level of significance was set at $p<0.05$ and the homogeneity of variance was determined with Levene’s test. To investigate the effect of sentence type, repeated measures analyses of variance were used. If there was more than one degree of freedom in the numerator, the Greenhouse-Geisser correction was applied (Stevens, 1996).

Spontaneous speech analysis

Per child, the whole sample of spontaneous speech was transcribed orthographically. The records of spontaneous speech were not equal in size and therefore it was decided to control for sample length by including 225 words of the sample for analysis. If more than 225 words had been uttered, the last portion of the recorded conversation was taken. The samples of 225 words were analysed with respect to the realisation of subject-verb agreement in an obligatory context (the presence of both a subject and a verb). All occurrences of (finite) verbs were counted: lexical verbs, auxiliaries and copula.

T-tests were used to compare the scores between the two groups.

5.2.4 Results

5.2.4.1 Reading tasks

The mean scores of the dyslexic and the CA children are displayed in Table 2. All dyslexic children had standard scores below 7, indicating subnormal performance (Van den Bos, 1998). All control children scored at least within or above the normative mean (standard scores between 7-13). The scores of the two reading tasks were significantly different: the dyslexic children always read fewer words correctly than the CA control children ($p<0.001$).

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7 This sample size was chosen as the shortest sample contained 225 words.
Table 2. The mean standard scores and standard deviations (SD) on the RWT and the PWT.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Dyslexia</th>
<th>SD</th>
<th>CA control</th>
<th>SD</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RWT</td>
<td>3.12</td>
<td>1.53</td>
<td>11.31</td>
<td>2.62</td>
<td>13.77</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>PWT</td>
<td>3.81</td>
<td>1.47</td>
<td>11.54</td>
<td>2.75</td>
<td>12.66</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

5.2.4.2 Grammaticality judgement task

The responses are shown in Figure 4. The percentages corresponding to the grammatical sentences reflect ‘hits’ (‘yes’ to a grammatical sentence) and the percentages corresponding to the ungrammatical sentences reflect ‘correct rejections’ (‘no’ to ungrammatical sentences). A one-way ANOVA revealed that judgement of the three types of agreement violations differed significantly between the three groups (F>4.5, p<0.002), but that the ability to judge the sentences containing incomplete PP’s was the same for the three groups (F(2,58)= 1.38, p=0.26).

To protect the data from a possible tendency to default to accepting sentences as grammatical, a one-way ANOVA for the A’ values was carried out to investigate group differences more precisely and accurately. The A’ measure of discrimination ability between grammatical and ungrammatical sentences differed significantly between the three groups: (type 1: F(2,58)=8.0, p=0.001, type 2: F(2,58)=7.9, p=0.001, type 3: F(2,58)=5.8, p=0.005). Games-Howell tests revealed that the dyslexic children always scored significantly lower than the CA controls and the RA control children (type 1: p<0.008, type 2: p<0.006, type 3: p<0.02), see Table 3.

Table 3. A’ values and standard deviations (SD) representing proportional scores of discrimination between grammatical and ungrammatical sentences.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Dyslexia</th>
<th>SD</th>
<th>CA Control</th>
<th>SD</th>
<th>RA Control</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>A’ type 1</td>
<td>0.85&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.15</td>
<td>0.96</td>
<td>0.04</td>
<td>0.95</td>
<td>0.03</td>
</tr>
<tr>
<td>A’ type 2</td>
<td>0.90&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.10</td>
<td>0.97</td>
<td>0.03</td>
<td>0.97</td>
<td>0.02</td>
</tr>
<tr>
<td>A’ type 3</td>
<td>0.86&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.14</td>
<td>0.94</td>
<td>0.07</td>
<td>0.96</td>
<td>0.03</td>
</tr>
</tbody>
</table>

<sup>a</sup>: means are significantly lower than CA control group (p<0.02)
<sup>b</sup>: means are significantly lower than RA control group (p<0.008)
5.2.4.2.1 Effect of violation type

No main effect was found for the type of agreement violation ($F(2,116)=2.0$, $p=0.14$), nor was there an interaction between group and type of agreement error ($F(4,116)=0.53$, $p=0.72$). The main effect of group was significant ($F(2,58)=13.99$, $p<0.001$).

5.2.4.2.2 Spontaneous speech

The group of dyslexic children produced significantly fewer obligatory contexts for subject-verb agreement (the presence of both a subject and a verb) than the CA control children (mean dyslexic children: 26.3, SD 4.6; mean control children: 32.3, SD 3.0; $t(18)=4.2$, $p<0.001$). In order to make a fair comparison between the two groups, it was decided to analyse the first twenty obligatory contexts of each child, meaning that only a subset of the total number of contexts produced was included in the analysis. The group of CA control children realised 99% of the strings consisting of a verb and a subject correctly. The dyslexic children had significantly more difficulty with producing the correct form of the agreement relation: in 17% of the instances in which they had expressed a subject and a verb, the inflection was incorrect (83% correct; $t(18)=3.7$, $p<0.004$). In total, the dyslexic children made 38 subject-verb agreement errors compared to 2 errors in the CA control group.
An analysis of the errors revealed two main types of errors in the dyslexic group: omitting the agreement marker /t/ (55.5% errors) in a sentence with a 3\textsuperscript{rd} person subject and expressing a singular verb in a sentence containing a plural subject (39% errors). Examples are:

**Omission of agreement marker /t/**

* en dan *ga* (1\textsuperscript{st}/2\textsuperscript{nd} person) iedereen slapen (and then everybody go to sleep)
Grammatical version: en dan *gaat* (3\textsuperscript{rd} person) iedereen slapen (and then everybody goes to sleep)

*het *lijk* (1\textsuperscript{st} person) net een bus (it look like a bus)
Grammatical version: het *lijkt* (3\textsuperscript{rd} person) net een bus (it looks like a bus)

**Plural inflection substituted with singular inflection**

*Dat *is* zulke grote poppetjes (those is such big dolls)
Grammatical version: dat *zijn* zulke grote poppetjes (those are such big dolls)

*We *ging* (singular) een beetje snel (we went a bit fast)
Grammatical version: we *gingen* (plural) een beetje snel (we went a bit fast)

In half of the instances in which the agreement marker /t/ was omitted, the produced verb form was the correct form for 1\textsuperscript{st} or 2\textsuperscript{nd} person singular inflection (e.g. *het *lijk* net een bus; *it look like a bus). It is therefore not clear whether these errors are substitution errors (in which 3\textsuperscript{rd} person singular inflection is substituted with 1\textsuperscript{st} or 2\textsuperscript{nd} person inflection) or omission errors (omission of the agreement marker). The other instances of /t/-deletion are clear cases of omissions: the produced verb form does not exist in Dutch (for instance: *wach* je *een tijdje* instead of *wacht* je *een tijdje* (you wai(t) a little while)). The spontaneous speech analysis of the CA control children showed that in this group the /t/ of the verb form was once deleted (of the two errors in total) and that once a singular verb form instead of a plural inflection was produced. It has to be noted here, that in colloquial Dutch, deletion of the verb inflection /t/ often occurs, depending on phonological context and the region of a speaker. The goal of this study was to compare agreement marking in dyslexic and non-dyslexic children, who were all from the same region. Therefore /t/ deletion has been marked for analysis. It is however acknowledged
that the agreement errors in case of plural subjects are more easy to interpret, as deletion of the syllable -en is not allowed in colloquial Dutch\(^8\).

### 5.2.5 Discussion

This study was undertaken to investigate sensitivity to agreement morphology in children with developmental dyslexia. Both an analysis of spontaneous speech and a grammaticality judgement task showed that dyslexic children have significantly more problems with subject-verb agreement than their normally reading peers. The dyslexic children were also outperformed by the reading level matched children, indicating that the decreased sensitivity to agreement morphology cannot be caused by a possible consequence of dyslexia: less exposure to print. These results fit in with the data of chapter 4 that showed that there is a difference in agreement performance between children at–risk for dyslexia and control children already at pre-reading age.

Recently, oral language abilities of children with developmental dyslexia have become the focus of attention. Evidence has come up suggesting that some dyslexic children could also be classified as having SLI (McArthur et al., 2000) or that at least they show a mild form of SLI (De Bree et al., 2003). The next study will address the relationship between developmental dyslexia and SLI and will also investigate relationships between phonological processing, subject-verb agreement and word decoding skills\(^9\).

### 5.3 Study 2

#### 5.3.1 Introduction

Study 1 showed that dyslexic children are less sensitive to agreement morphology than children without dyslexia, both matched on chronological age and on reading level. This observation adds to other evidence of (subtle) impairment in spoken language of children with developmental dyslexia.

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\(^8\) The –n of the agreement marking suffix –en is often dropped in spoken language and therefore realisation of –e as an agreement marker was also counted as correct.

\(^9\) See also Rispens & Been (2004; in press).
The next step is attempting to understand the relationship between the various symptoms that all cluster in dyslexia with respect to the mechanism(s) of the reading and spelling breakdown. Three assumptions regarding such a relation have been discussed in chapter 2. The first was that oral language development may be hampered due to the consequences of dyslexia (less access and exposure to print). This hypothesis can be rejected on the basis of the results of the experiments in chapter 4 and Study 1. In these experiments it was found that dyslexic children at pre-reading age were significantly poorer on detecting agreement violations relative to normally developing children. Furthermore, children of around 7 years of age without dyslexia, but who had the same reading level as older dyslexic children, were significantly more sensitive to subject verb agreement than children with dyslexia.

The two other views on grammatical development in dyslexia will be discussed below (and see chapter 2).

(1). Grammatical deficits in dyslexia: a consequence of the phonological deficit underlying word decoding difficulties?

Grammatical limitations in dyslexia have been related to the difficulties with processing phonological information that may underlie the reading impairment. Note that such a view aims toward a unitary explanation of dyslexia: all symptoms observed in dyslexia (the literacy deficit, but also the phonological, lexical-semantic and syntactic problems) spring from the same source.

Mann et al. (1984), Smith et al. (1989), Crain & Shankweiler (1990) and Bar-Shalom et al. (1993) hypothesise that problems in accessing and processing phonological information affect the processing of linguistic information at a higher level (i.e. syntactic level), but that the syntactic representations themselves in the language systems of children with developmental dyslexia are intact. They take the language system to be modular, in which linguistic information flows from and to the different levels of the language apparatus (phonology, semantics and syntax) where it is processed separately. The verbal working memory (WM) system enables the storage of information (via the phonological loop), and the transfer of information between the different levels (via the central executive system). Shankweiler and co-workers propose that the phonological deficit of dyslexic people interferes with the first step in the language model (computing and temporarily storing a phonetic code of the incoming language stream), affecting processing at all other levels.
In this view, there is more pressure on the verbal WM system in dyslexic subjects relative to subjects without dyslexia in the sense that the storage and transfer of phonological information to the different levels within the language system is limited in dyslexic individuals. An assumption derived from this is that linguistic information that does not particularly stress verbal WM will be processed normally, in contrast to information that places heavy demands on the verbal working memory system. It is important to note that the inherent complexity of a syntactic representation is not the key factor for dyslexic subjects determining success of comprehension. Rather, correct processing depends on the demands that the linguistic information makes on the WM system.

Evidence that illustrates this hypothesis was gathered in an experiment that tested children’s auditory comprehension of sentences containing temporal terms (Crain & Shankweiler, 1990). Temporal terms like ‘before’ and ‘after’ in a sentence present a child with a sequential mismatch, as illustrated in sentence (1) and (2):

(1). Push the motorcycle after you push the helicopter
(2) Before you push the motorcycle, push the helicopter

The sequential problem arises as the order in which the objects are being heard, is not the order in which the instruction needs to be carried out. Verbal WM is supposed to play a role in the understanding of this sentence, as the phonological information needs to be kept activated long enough for the listener to extract the conceptual representation (ordering of the sequence in which the action needs to be carried out) from the linguistic representation. According to Crain & Shankweiler (1990), there is another reason for sentences like (1) and (2) to be taxing the verbal WM system. Sentences (1) and (2) presuppose that a listener intends to push the helicopter, and in order to satisfy that presupposition pragmatically, a subject should have established this intention before the command is given. In the example sentences, the pragmatic conditions are not met and subjects need to accommodate this in their mental model of the discourse. Such a revision

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10 Smith et al., (1989), Crain & Shankweiler (1990) and Bar-Shalom et al. (1993) are not particularly clear in stating what factors determine the processing load linguistic information puts on verbal WM. They propose a deficit in phonological processing (i.e., maintaining and reactivating phonological information) to affect the flow of information to the syntactic and semantic parsers. Hence, one would expect that phonological complexity affects syntactic (or semantic) parsing. However, the researchers test their hypothesis by varying non-phonological factors such as pragmatic conditions or experimental context in their experiments.
of this mental model is costly in terms of processing resources, which in turn affects the chance of adequate comprehension. Thus, according to Crain & Shankweiler (1990), it is the pragmatic oddity of the context of the test sentences that elicit the errors (due to a high loading on the WM system), rather than a difficulty with processing temporal terms per se.

A new design of an experiment testing auditory comprehension of temporal terms in dyslexia addressed the issue of meeting the presupposition involved in relative clauses introduced with terms such as ‘before’ and ‘after’ (Crain & Shankweiler, 1990). Before presenting the test sentence, a child was asked with which toy s/he wanted to play in the next part of the game. The toy that the child picked was used as the object of the subordinate clause that started with the temporal term. Children with and without dyslexia were tested in this condition, and in the condition in which the presupposition was not met. It turned out that children with reading disability profited more from the design that did not violate the presupposition than the normally reading children, which, according to Crain & Shankweiler (1990) shows that when demands on verbal WM are lifted, performance increases.

Not only phonological processing limitations but also impaired phonological awareness has been identified as a causal factor in grammatical deficits, in particular in the domain of morphosyntactic rule learning. Joanisse et al. (2000) discuss their findings of impaired tense formation in developmental dyslexia in the light of phonological segmentation limitations and speech perception deficits which may interfere with building up a stable inflectional paradigm. They found that dyslexic children with impaired phonological awareness had more trouble with inflecting verbs for the past tense than normally reading children matched on reading level, but that dyslexic children who in addition to decreased phonological awareness, showed impaired speech perception displayed more severe deficits in inflectional morphology. Thus, impairments in the ability to segment off sounds within phonological representations seem to impact on the ability to manipulate the phonological representations of verbs to mark them or to recognise the morphemes that mark them for tense. Joanisse et al. (2000) use these findings to underline the phonological component of morphological rules. Generating a past tense paradigm in English requires an appreciation of the phonological structure of the verb stem as there are three tense marking morphemes (/t/, /d/, /Id/). The selection of a tense marker depends on the phonological features of the phoneme in the coda position of the verb stem (cf. walked, rained, pleaded). Thus, speech perception problems may
lead to ‘fuzzy’ phonological representations, which in turn may interfere with morphosyntactic rule learning.

In Study 2, the syntactic relation between a subject and the verb, expressed by an agreement morpheme, is under investigation. How can limitations of the verbal WM system and/or speech perception and/or phonological analysis cause problems with subject-verb agreement for Dutch speaking children? Like marking a verb for tense, marking a verb for agreement with the subject has a phonological component. Children need to realise that certain phonemes are added to a stem of the verb to mark agreement. In Dutch there is a null form (1st person singular and 2nd person singular in inverted sentences; *ik ren* (I run), *ren jij* (run you)), the verb stem plus /t/ (2nd person singular and 3rd person singular; *jij rent* (you run), *hij rent* (he runs)) and the stem form plus /en/ in case of plural (*wij rennen* (we run)). Thus, when processing speech, a child does not only need to be able to perceive the different phonemes of the verb, but also has to realise that the perceived verb forms consist of fixed stems on which agreement marking phonemes may be added. This process may be advanced if a child is able to segment off and manipulate the syllables and or phonemes a word consists of.

Furthermore, verbal WM is likely to be implicated in the process of learning the paradigm of agreement. Agreement marking of the verb has a dependency relationship with the subject of the sentence. Accordingly so, the surface form of the verb depends on the subject. The features ‘number’ and ‘person’ of the subject of the sentence therefore need to be kept active long enough in memory in order to link the verb to the subject. If verbal WM is limited, regardless of whether this is due to the quality of the phonological representation or to a limitation of the system itself, it can be envisaged that an impairment in the activation of the linguistic information of the subject (number and person features), affects the ability to mark a verb for agreement with the subject of the sentence. Study 2 will test whether auditory perception, verbal working memory and phonological awareness are indeed related to subject-verb agreement.

(2) Grammatical deficits in dyslexia: reflections of delayed development of the grammatical system?

Other researchers view the syntactic limitations observed in dyslexic children independently from possible phonological deficits. The so-called ‘structural lag’ hypothesis suggests that dyslexic children are delayed in their development of grammatical knowledge (Byrne, 1981), thus pinpointing the mechanism underlying the poorer syntactic
performance of dyslexic children compared to normally developing children within the grammatical system, rather than to processing limitations. This view separates the phonological (processing) difficulties from the syntactic limitations that dyslexic children experience. Byrne (1981) found that sentences which only differed in the underlying syntactic form, but not in the phonetic surface form (e.g.: *John is easy to please* versus *John is eager to please*) elicited a between-group difference in children with and without reading disabilities. As, according to Byrne (1981), no differences in phonological processing demands existed between the two sentence types, these data give evidence for a syntactic delay in children with reading disability.

Another issue is whether syntactic skills actually contribute to reading ability independently from phonological skills. Catts et al. (1999) support the latter assertion. They showed that a composite score of several oral language measures contributed a small but significant amount of unique variance to word recognition. Catts et al. (1999) recognise the role of oral language with respect to the development of word recognition skills especially in contextual facilitation. An impairment in oral language may prevent a child from using word context to facilitate word recognition which in turn affects the building up of fully developed representations for printed words.

In Study 2, the relationship between word recognition and decoding and subject-verb agreement will be explored to investigate the idea that grammatical skills impact on word recognition and decoding ability.

### 5.3.2 Two opposing views on morphosyntactic deficits in SLI

So far, two different hypotheses on grammatical breakdown in developmental dyslexia have been sketched: (1) grammatical deficits stem from phonological (processing) limitations, and (2) the development of syntactic principles are delayed in children with development dyslexia independently of their phonological problems. The same dichotomy in the theoretical explanations of the morphosyntactic problems in children with SLI can be found. Below, two opposing views will be outlined.

A well-known theoretical explanation of morphosyntactic deficits observed in SLI is the Extended Optional Infinitive Stage (EOIS), proposed by Rice & Wexler (1995) and adapted by Wexler et al. (1998). This account explains morphosyntactic impairments in SLI as a delay of a developmental stage (the optional infinitive stage) that children go through. The optional infinitive stage refers to a period (between the ages of 1;10 until
approximately 3;6 in normally developing children) in which marking of agreement and tense is optional, due to incomplete knowledge of the syntactic features of ‘Tense’ and ‘Agreement’. Such an optionality of these syntactic features therefore explains the observed omissions of grammatical morphemes such as third person singular, copula’s, auxiliaries and past tense, but also the observation that children produce such grammatical markers correctly. Thus, utterances like ‘he eat cookie’ and ‘he eats cookie’ alternate during that period of time. When children are around 3;06-4;06 of age, the ‘Tense’ and ‘Agreement’ features will have most likely been fully specified in their language systems, meaning that tense and agreement marking is no longer optional. Children will thus show adult-like use of grammatical features that are dependent of the specification of ‘Tense’ and ‘Agreement’.

Children with SLI are hypothesised to have an extended period of such an optional grammar, meaning that in their immature grammars the syntactic features ‘Tense’ and ‘Agreement’ remain optional. Following this account, this optionality is responsible for the omission of morphosyntactic markers. Thus, in this view the language behaviour of children with SLI reflects an immature grammar, rather than a language system that is inherently different from that of normally developing children.

Other modular accounts of language impairment in SLI, placing the locus of the deficit within the grammatical system rather than attributing it to non-syntactic factors, view the grammar of SLI children to be different from that of normally developing children, rather than delayed. For instance, Van der Lely and co-workers (Van der Lely, 1996; Van der Lely & Stollwerck, 1997), propose that grammatical problems of children with SLI (labelling this subgroup G-SLI) stem from a ‘representational deficit for dependent relationships’ which interferes with tense marking, binding of a pronoun with an antecedent and interpretation of passive sentences.

In sharp contrast to such modular explanations for SLI are the so called ‘processing accounts’, which propose that limitations in auditory perception, or the ability to process phonological information may impact on grammatical behaviour. Examples of such ‘processing accounts’ are the surface hypothesis of Leonard (1989; 1998) and the account of Joanisse & Seidenberg (1998) in which speech perception deficits and verbal WM problems are related to poor morphosyntactic behaviour.

Leonard (1989) takes the language-learning mechanisms of children with SLI to be following the same principles as these of non-language impaired children. He bases his view of morphosyntactic development on Pinker’s (1984) account, which entails that children create inflectional paradigms that specify the affixes which mark certain linguistic
features. Initially, word-specific paradigms are formed, but gradually in the course of language development, the paradigms become general. In this stage, the child ‘knows’ the affixes representing a certain syntactic feature, such as number or past tense, and can apply these to a new learned word. Affixes are not all acquired at the same time, instead there seems to be a ranking order. Pinker (1984) argues that several aspects of affixes determine the order of development. For example, affixes that are perceptually not very salient are unlikely to be the first ones to be acquired, in contrast to morphemes that are perceptually salient or have clear semantic functions (such as the plural –s in English).

Children with SLI do not have difficulty with the formation of a paradigm in itself, but, according to Leonard (1989), the principle problem that interferes with building up paradigms in SLI is distortion of the input due to their auditory perceptual difficulties. In particular, grammatical morphemes that have perceptually unsalient acoustic features are at risk of not being perceived or processed. With these unsalient morphemes are meant ‘nonsyllabic’ segments and unstressed syllables, characterised by shorter duration than adjacent morphemes, and, often lower fundamental frequency and amplitude (Leonard, 1989: 186). Thus, limitations in the ability to perceive grammatical elements, and process the information they convey, restrain the development of general inflectional paradigms for children with SLI (Leonard, 1989; 1998).

Cross-linguistic studies show that in languages in which grammatical morphemes are more salient than in English (the language that is researched most often), for example Italian, such grammatical morphemes are more preserved in the speech of SLI children (Leonard, 1989). Such evidence supports the idea that the acoustic properties of affixes play an important role in the ability of children with SLI to process these.

Joanisse & Seidenberg (1998) also explain morphosyntactic problems in SLI as stemming from auditory deficits, comparable to the way they account for morphosyntactic problems in dyslexia (see 5.3.1.). They claim that auditory perceptual deficits interfere with the development of phonological representations, in the way that has been discussed previously and that degraded phonological representations are “the proximal cause of deviant acquisition of morphology and syntax, by virtue of their roles in learning and working memory” (1998: 241). Furthermore, phonological deficits need not necessarily stem from a perceptual deficit but can nevertheless hamper morphosyntactic development. Joanisse et al. (2000) state:

“impairment in analysing phonological structure affects acquisition and automatisation of morphological patterns of, for example, past tenses” (2000: 52).
Again, the property of the phonological form of the tense marker depends on the stem of the verb, which is difficult for children who are impaired in the phonological segmentation of a word. Thus, auditory perceptual problems may prompt phonological and, consequently, morphosyntactic deficits, but the latter can also arise from problems related to a difficulty in analysing phonological structure that is not associated with speech perception deficits.

Data of Bishop et al. (1999) are in line with the idea that language impairment is not necessarily related to auditory deficits. They did not find a link between auditory impairment and SLI as children with SLI did not differ from control children on a number of tasks tapping auditory perception. Furthermore, they found that a proportion of the control children, who showed normal language skills, performed poorly on the auditory measures (below the 10th percentile), which does not support the idea that auditory deficits cause language impairments. The authors do not want to abandon the idea that auditory perceptual skill plays a role in language ability, but rather than viewing it as the main influence, they propose it to be one of multiple factors that act synergistically in triggering language impairment.

To elucidate effects of auditory perception on morphosyntactic skills, Norbury et al. (2001) investigated finite verb morphology in children with a sensorineural hearing impairment and compared them to children with SLI. As expected, this latter group displayed impaired marking of finite verb morphology, in contrast to the hearing impaired children who, as a group, did not differ from the control subjects. However, one fifth of these children did meet the criteria of language impairment and had morphosyntactic difficulties; a higher than expected proportion of a population (the average risk for SLI is 7% (Catts et al., 1997)). As this subgroup consisted of the youngest children of the hearing impaired group, the investigators suggest disrupted auditory processing to delay development of inflectional marking, but follow-up studies have to be carried out to maintain this claim. In addition, the SLI children who performed poorly on production of finite verb morphology were also impaired on tasks that have a high loading on verbal short term memory (non-word repetition and recalling sentences), in contrast to the children of the hearing impaired group who performed within normal limits on recalling sentences. The main conclusion drawn from this study is that perceptual problems are not a sufficient explanation for morphological difficulties, but that, instead, higher level phonological memory and processing limitations may be related to grammatical deficits.
5.3.3  Dyslexia and SLI: is there a difference?

By comparing the symptoms and theoretical explanations of dyslexia and SLI, the picture emerges that the same issues surface in the description and theoretical considerations in both syndromes\textsuperscript{11}. Children with dyslexia and SLI may experience auditory, phonological, and morphosyntactic problems which may or may not be interrelated. Not surprisingly, a frequently raised question is whether dyslexia and SLI are manifestations of the same underlying disorder, with the difference being the severity of the problems or whether they are in fact two separate clinical entities with qualitatively different deficits underlying the disorders. In chapter 2, different views and issues on this matter have been discussed. In sum, two opposing views were put forward: dyslexia and SLI are two manifestations of the same underlying disorder (Tallal et al., 1997) and dyslexia and SLI are two qualitatively different phenomena (Snowling et al., 2000).

In the following experiment, children with dyslexia will be compared with children with SLI. What can these data tell us about a possible link between the two syndromes? First of all, it will be investigated whether the children of the two populations show the same types of deficits in the areas of auditory processing, phonological awareness, verbal WM, morphosyntax and literacy skills. If dyslexia is indeed related to SLI, in the sense that it represents a 'lighter' version, then the two groups are expected to show the same types of deficits, with the dyslexic children possibly scoring better than the SLI children. It is acknowledged here that genetic research and neuro-imaging studies seem to be invaluable for a deeper insight into the nature of language and literacy problems in the two groups. However, the data of Study 2 will be used to index behavioural profiles of the two syndromes and to see whether and to what extent such typologies overlap. If they do, the question what this overlap actually reflects may be addressed.

5.3.4  Research questions

In Study 2 the two hypotheses on the relation between phonology, morphosyntax and literacy will be tested and the following research questions will be addressed in this chapter:

\textsuperscript{11} For the sake of readability, SLI and dyslexia are referred to as two syndromes, even though they may be actually stemming from the same underlying disorder.
(1) Is the level of sensitivity to agreement morphology of children with developmental dyslexia comparable to that of children with SLI?

(2) Are agreement deficits in both experimental groups related to impairments in auditory perception, phonological awareness and verbal working memory?

(3) What do the data tell us about the relationship between subject-verb agreement, auditory perception, phonological awareness, verbal working memory and word decoding/recognition skills?

5.4 Method

5.4.1 Subjects

Children with developmental dyslexia

Twenty children with developmental dyslexia (12 boys, 8 girls; mean age 8;08) participated in this study. Children who matched the children with SLI on chronological age were selected from a larger sample that participated in Study 1. For a description of the selection criteria, see Study 1. None of the dyslexic children had phonological/phonetic output problems.

Children with SLI

Twenty-one children with SLI (14 boys, 7 girls; mean age 8;05) were recruited from special schools for children with language impairment. The criteria of inclusion in the SLI group were a language impairment diagnosed by a speech and language therapist on the basis of standardised Dutch language tests, at least average non-verbal IQ, measured by educational specialists as part of the review process in school (using SON 21/2-7 (Tellegen et al., 1998) or the RAKIT (Bleichrodt et al., 1987) test batteries), being a native speaker of Dutch and absence of any neurological deficits. None of the SLI children had phonological/phonetic output problems.
**Chronological Age control group**

The chronological age control group consisted of 18 Dutch children, who all but one participated in Study 1 and matched the dyslexic and the SLI children on chronological age (9 boys, 9 girls; mean age 8;08). None of the control children had phonological/phonetic output problems.

### 5.4.2 Materials

#### 5.4.2.1 Grammaticality judgement task

See Study 1.

#### 5.4.2.2 Reading tasks

The standardised RWT and PWT were administered to assess word recognition and decoding skills (see Study 1 for more information about the tasks).

#### 5.4.2.3 Phonological tasks

**Identification of speech sounds:** Children were asked to identify a stimulus as ‘bak’ or ‘dak’, using a synthetic continuum, developed by Schwippert (1998). These speech sounds differ with respect to their second formant. Using a computer, the stimulus ‘bak’ was turned into ‘dak’. This was done by raising the initial 1100 Hz in the second formant of a ‘bak’ stimulus, spoken aloud by a female native speaker of Dutch, in 9 equal steps of 78 Hz to 1800 Hz in a 100 ms interval. This resulted in 10 stimuli along a synthetic continuum. In this experiment, stimuli 3 and 6 of the synthetic continuum were presented for identification. The perception of stimulus 3 is ‘bak’, and that of stimulus 6 is ‘dak’. Ten stimuli representing ‘bak’ and ten stimuli representing ‘dak’ were presented in a random order to the subjects using headphones.

The task was scored in percentages correctly identified.
Auditory discrimination: Discrimination between the speech sounds ‘bak’ and ‘dak’ was assessed, using the stimulus pair 3-6 of the synthetic continuum as described above. Children were presented with two stimuli via headphones and were asked whether these two stimuli sounded the same. Children showed their response by either saying ‘yes’ (to confirm that the two sounds sounded the same) or ‘no’ (to indicate a mismatch). The Interstimulus Interval (ISI) was set at 800 ms. Twenty stimuli were presented, of which ten were identical stimulus pairs.

The task was scored in percentages correctly discriminated.

Phonological awareness: A phoneme deletion task was developed to assess phonological awareness. Thirty words were presented auditorily to the child who was asked to repeat the word without a specified sound (for example: can you say ‘vlo’ without the /v/?). That sound was either the first phoneme of a consonant cluster (10 words), the second phoneme (10 items) of a consonant cluster or the last phoneme of the word (a singleton) (10 items). The remaining word was a non-word, except for five words, see Appendix II for a list of the items.

The score was the number of words repeated back correctly; the maximum score was 30.

Verbal working memory: Three tasks to tap verbal working memory were administered.

Digit Span: The digit span tasks ‘forward’ and ‘backward’ of the Dutch version of the WISC-R (Van Haasen et al., 1986) were used. Children were presented auditorily with series of numbers (forward: starting from 3-8 digits in a row, backward: 2-7 digits) and were asked to repeat them back. In the ‘backward’ version, the child was presented with a series of digits and the child was instructed to repeat these digits in the reversed order.

Both digit span tasks have a loading on the verbal WM system. The difference between the two tasks is that the ‘forward’ subtest measures the capacity of the phonological loop (the subjects need to rehearse the digits), whereas in the ‘backward’ version of the digit span task not only the phonological loop is involved, but a subject also needs to manipulate the verbal material in which the central executive system plays a role. Therefore, the ‘backward’ digit span subtest may be viewed as a measure of overall verbal WM capacity, rather than measuring one of its components, as the ‘forward’ test does (Bowey et al., 1992).
Each list length consisted of two separate items. If the child failed to repeat two items of the same category correctly, testing was discontinued.

Digit span forward and backward were scored separately. Each item that was repeated back correctly was awarded with one credit; the maximum score per task was 12.

**Non-word repetition:** The task reported in de Bree et al. (2003) was used. This task contains 19 non-words that consisted of 1-5 syllables in length, see Appendix III for the items. Of all 19 non-words, 1 item consisted of 1 syllable, 5 items of 2 syllables, 4 items of 3 syllables, 5 items of 4 syllables and 4 items of 5 syllables. The syllables in the non-words and the non-words as a whole were not Dutch lexical items, but they conform to the Dutch phonotactic rule system. The items were spoken aloud by a female native speaker of Dutch and were recorded on a computer. The non-words were played back to the subject on a laptop computer via headphones. Repeated presentations of the items were not allowed. The responses of the subjects were recorded on audio tape and were transcribed after the testing session.

The score was the number of items repeated back correctly. The maximum score was 19.

**Sentence Recall:** The task ‘repetition of sentences’ of the Dutch version of the WPPSI-R (VanderSteene & Bos, 1997) was used. It includes 12 sentences of increasing length and complexity to assess sentence recall. In addition, 3 syntactically complex sentences (two relative clauses and a passive sentence) were constructed and added to the task, to make sure that the task was not too easy for the children as the WPPSI sentence recall test has been standardised for children up to 7;06 years of age (for the test items see Appendix IV). Sentences were spoken aloud by a female native speaker of Dutch and were recorded on a computer. The items were presented via headphones on a laptop computer to the subjects. The responses of the subjects were recorded on an audio tape and were transcribed orthographically after the testing session. The items were only once presented to the child.

Each sentence that was repeated back correctly was awarded with one credit, the maximum score being 15.
Figure 5 provides an overview of the tasks used in Study 2.

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grammaticality judgements</td>
<td>Morphosyntax</td>
</tr>
<tr>
<td>Real word reading</td>
<td>Word recognition</td>
</tr>
<tr>
<td>Pseudo-word reading</td>
<td>Word decoding</td>
</tr>
<tr>
<td>Speech identification</td>
<td>Speech perception</td>
</tr>
<tr>
<td>Speech discrimination</td>
<td>Speech perception</td>
</tr>
<tr>
<td>Phoneme deletion</td>
<td>Phonological awareness</td>
</tr>
<tr>
<td>Digit span</td>
<td>Verbal working memory</td>
</tr>
<tr>
<td>Non-word repetition</td>
<td>Verbal working memory</td>
</tr>
<tr>
<td>Sentence recall</td>
<td>Verbal working memory</td>
</tr>
</tbody>
</table>

Figure 5. An overview of the tasks administered in Study 2.

5.4.3 Procedure and data analysis

The tasks were administered individually in a quiet room at school, or in a room at the dyslexia research centre spread over two sessions. The results of one control subject on the speech identification task and the results of two control subjects on the auditory discrimination task were not analysed due to technical problems during data collection.

The results on the tasks were compared between the three groups using a Univariate one-way ANOVA with Scheffé tests and Games-Howell tests in case of unequal variances to investigate post-hoc any group differences. In case of comparisons between two groups, T-tests were used.
5.4.4 Results

Table 4 presents an overview of the results.

Table 4. Mean scores and standard deviations (SD) of the children with developmental dyslexia, SLI and the control group.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Dyslexia (SD)</th>
<th>SLI (SD)</th>
<th>Control (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in months</td>
<td>104 (8)</td>
<td>101 (4)</td>
<td>104 (6)</td>
</tr>
<tr>
<td>Subject-verb agreement</td>
<td>0.9&lt;sup&gt;a&lt;/sup&gt; (0.07)</td>
<td>0.56&lt;sup&gt;ab&lt;/sup&gt; (0.18)</td>
<td>0.96 (0.03)</td>
</tr>
<tr>
<td>Pseudo Word decoding (PWT)</td>
<td>4.1&lt;sup&gt;ac&lt;/sup&gt; (1.5)</td>
<td>7.4&lt;sup&gt;a&lt;/sup&gt; (3.7)</td>
<td>12 (2.7)</td>
</tr>
<tr>
<td>Real Word recognition (RWT)</td>
<td>3.1&lt;sup&gt;ac&lt;/sup&gt; (1.5)</td>
<td>6.1&lt;sup&gt;a&lt;/sup&gt; (3.3)</td>
<td>11.9 (2.7)</td>
</tr>
<tr>
<td>Speech identification</td>
<td>79% (17%)</td>
<td>74% (19%)</td>
<td>82% (18%)</td>
</tr>
<tr>
<td>Speech discrimination</td>
<td>77% (16%)</td>
<td>57%&lt;sup&gt;b&lt;/sup&gt; (22%)</td>
<td>75% (21%)</td>
</tr>
<tr>
<td>Phonological awareness (max 30)</td>
<td>18.7&lt;sup&gt;a&lt;/sup&gt; (6.7)</td>
<td>19.3&lt;sup&gt;a&lt;/sup&gt; (8.7)</td>
<td>26.7 (3.2)</td>
</tr>
<tr>
<td>Digit span forward (max 12)</td>
<td>5.9 (1.9)</td>
<td>3.3&lt;sup&gt;ab&lt;/sup&gt; (0.9)</td>
<td>6.1 (1.5)</td>
</tr>
<tr>
<td>Digit span backward (max 12)</td>
<td>3.7&lt;sup&gt;a&lt;/sup&gt; (1.2)</td>
<td>3&lt;sup&gt;a&lt;/sup&gt; (1.3)</td>
<td>4.6 (1.2)</td>
</tr>
<tr>
<td>Non-word repetition (max 19)</td>
<td>10.7&lt;sup&gt;a&lt;/sup&gt; (2.7)</td>
<td>5.5&lt;sup&gt;ab&lt;/sup&gt; (1.9)</td>
<td>12.7 (2)</td>
</tr>
<tr>
<td>Sentence recall (max 15)</td>
<td>8.1&lt;sup&gt;a&lt;/sup&gt; (1.1)</td>
<td>6.5&lt;sup&gt;ab&lt;/sup&gt; (1.4)</td>
<td>9.1 (1.2)</td>
</tr>
</tbody>
</table>

<sup>a</sup> Score significantly lower than control group on Scheffé/Games Howell test set at \( p < 0.05 \)

<sup>b</sup> Score significantly lower than dyslexic group on Scheffé/Games Howell test set at \( p < 0.05 \)

<sup>c</sup> Score significantly lower than SLI group on Scheffé/Games Howell test set at \( p < 0.05 \)

5.4.4.1 Grammaticality judgement task

The judgement task consisted of three types of agreement violations and a control condition to assess general meta-linguistic ability. None of the children of the control and dyslexic group showed problems with this control condition, in contrast to the SLI children. Ten of the 21 children scored less than 75% correctly on this condition, indicating that they either suffered from a severe syntactic impairment, or that their meta-linguistic skills were not fully developed yet. Such a problem with meta-linguistic awareness interferes with the interpretation of their results on the agreement conditions, as the scores in that case do not reflect a true indication of their morphosyntactic ability. Therefore, the ten children who ‘failed’ the control condition were excluded from the SLI
sample and their results on this task and on the other tasks were not analysed any further.\footnote{The ten children that failed the control condition did not differ statistically from the 11 other children with SLI on the subject-verb agreement condition of the judgement task. Nevertheless, it was decided to only include data of those children who passed the control condition in order to be able to interpret the data.}

Table 5 shows the mean A’ values (see 5.2.3.3) of the three agreement conditions and the percentages correct on the control condition. A one-way ANOVA revealed a significant group effect for the three agreement conditions (type 1 $F(2,46)=60$, $p<0.001$, type 2 $F(2,46)=39.1$, $p<0.001$, type 3 $F(2,46)=27.4$, $p<0.001$). Games-Howell tests showed that the dyslexic children performed significantly worse than the control children on type 1 and 2 ($p<0.012$), and that there was a non-significant trend for type 3 ($p=0.087$). The SLI children always performed significantly poorer than the dyslexic and control children on all three types ($p<0.003$).

As there was no effect of the type of violation ($F(2,92)=0.81$, $p<0.43$), nor an interaction between group and type of violation ($F(4,92)=0.88$, $p<0.46$), a mean score of all three types of agreement violations was calculated, see Table 4. A one-way ANOVA revealed significant group differences ($F(2, 46)=61.9$, $p<0.001$), with the control children outperforming the dyslexic children ($p<0.003$) and the SLI children ($p<0.001$), and the dyslexic children outperforming the SLI children ($p<0.001$). Note that the mean A’ value of the SLI group is around 0.5, indicating that their group performance does not exceed chance-level ($t(10)=1.0$, $p=0.31$). The dyslexic children and the controls perform well above chance-level.

Performance on the grammaticality judgement task was not ‘all or nothing’. Especially the SLI children, but also the dyslexic children to a lesser extent, do not all score similarly on the task. Two SLI children demonstrate the ability to detect agreement violations, attaining overall A’ values over 0.8 and two children show on at least one of the three agreement conditions a high discrimination ability, demonstrating at least some sensitivity to agreement information.

The dyslexic children also show some variability in their ability to detect agreement violations, not only between the individuals, but also, like the SLI children, between the three conditions. Eight children scored across the three conditions more than 2 standard deviations below the normative mean (normative mean A’ value of 0.96, SD 0.03) and two children had A’ values of less than 0.65 on one condition (indicating performance at chance-level), but A’ values of more than 0.9 on another condition.
Table 5. Mean A’ values and the standard deviations (SD) on the three types of agreement conditions and the mean percentages correct of the control condition of the grammaticality judgement task.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Dyslexia</th>
<th>SD</th>
<th>SLI</th>
<th>SD</th>
<th>Control</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>A’ type 1</td>
<td>0.89</td>
<td>0.08</td>
<td>0.6</td>
<td>0.15</td>
<td>0.96</td>
<td>0.04</td>
</tr>
<tr>
<td>A’ type 2</td>
<td>0.92</td>
<td>0.05</td>
<td>0.53</td>
<td>0.28</td>
<td>0.97</td>
<td>0.03</td>
</tr>
<tr>
<td>A’ type 3</td>
<td>0.88</td>
<td>0.12</td>
<td>0.55</td>
<td>0.25</td>
<td>0.95</td>
<td>0.06</td>
</tr>
<tr>
<td>Control condition</td>
<td>97%</td>
<td>6%</td>
<td>88%</td>
<td>12%</td>
<td>97%</td>
<td>7%</td>
</tr>
</tbody>
</table>

5.4.4.2 Results of reading tasks

Pseudo Word Reading task:
The standard scores of all dyslexic children were below 7 (range 1-6), indicating subnormal performance (Van den Bos, 1998). Five SLI children had impaired decoding skills (standard scores ranging from 2-6), six SLI children had standard scores indicating normal word decoding skills (range 7-13), and all control children obtained standard scores of 7 or higher (range 7-17), indicating normal word decoding skills, see Table 4 for group averages.

Real Word Reading task:
Table 4 displays the mean standard scores of all three groups. The standard scores of all dyslexic children were below 7 (range 1-5), indicating subnormal performance (Van den Bos, 1998). Seven SLI children scored below the normative mean (range 1-6) and four SLI children obtained standard scores of 7 or higher (range 7-11). Two SLI children had normal standard scores on the PWT, but scored subnormally on the RWT. All control children obtained standard scores of 7 or higher (range 8-18).

5.4.4.3 Results of phonological tasks

Auditory identification and discrimination:

Identification:
The mean scores correct are displayed in Table 4, indicating that the average scores of the three groups are all above chance-level. A one-way ANOVA showed that there were no
significant group differences \( F(2,44)=0.65, p=0.53 \). Figure 6 displays the distribution of the scores within the three groups, demonstrating considerable variability, with individuals from all three groups scoring from below chance-level (1 control subject 30% correct), at chance-level (dyslexic, control and SLI subjects scoring around 50% correct) and above chance-level (the majority of all three groups).

**Figure 6: The distribution of the mean percentages correct on the identification task.**

**Discrimination:**
A one-way ANOVA showed a significant group effect \( F(2,43)=4, p=0.025 \) on the auditory discrimination of the representations of ‘bak’ and ‘dak’. The children with SLI made significantly more errors than the dyslexic children. The average score of the children with SLI was around 57% correct, a score that does not exceed chance-level, in contrast to the dyslexic and control children (mean scores 77% and 75% correct). Figure 7 shows the distribution of scores, reflecting the range of scores from below-chance level in the SLI group, at-chance level in all three groups and above-chance level in all three groups.
Figure 7. The distribution of scores on the auditory discrimination task.

**Phonological awareness:**

In Table 4, the mean scores for all three groups are displayed. A one-way ANOVA revealed group differences ($F(2,44)=8.3$, $p=0.001$) and Games-Howell tests showed that the children with developmental dyslexia and SLI made significantly more errors than the controls (dyslexic subjects: $p<0.001$; SLI: $p<0.05$), but that there was no difference between the dyslexic children and the children with SLI ($p=0.98$).

**Verbal working memory:**

**Digit span forward:**
A one-way ANOVA showed group differences ($F(2,44)=12.2$, $p<0.001$), and as indicated by Games-Howell tests in Table 4, the children with SLI performed more poorly than the dyslexic and control children ($p<0.001$), whereas the dyslexic children performed alike the controls ($p=0.92$).

**Digit span backward:**
A one-way ANOVA showed an effect of group ($F(2,44)=6.6$, $p=0.003$) and Games-Howell tests revealed that both the dyslexic and SLI group had lower scores than the
controls (dyslexic subjects: p=0.05; SLI: p=0.007). No difference between the dyslexic and SLI children was detected (p=0.33), see Table 4.

**Non-word repetition:**
Table 4 displays the mean scores correct. A one-way ANOVA confirmed an overall difference between groups (F(2,44)=8.3, p<0.001) and Scheffé tests showed that the dyslexic children performed more poorly than the controls (p=0.04), but better than the children with SLI (p<0.001).

**Sentence recall:**
A one-way ANOVA indicated a main effect of group (F(2,44)=16.2, p<0.001) and Scheffé tests showed that the dyslexic and SLI children had significantly lower scores than the control group (dyslexic group: p=0.05; SLI: p<0.001) and that the children with SLI performed more poorly than the dyslexic children (p=0.003). See Table 4 for a mean score of the items repeated correctly.

5.4.5 Relationships between morphosyntax, phonological processing and literacy

Three possible relationships between morphosyntax, phonological processing and literacy have been sketched. One is that reading experience promotes morphosyntactic skills, a hypothesis that was not confirmed in Study 1. A second one is that phonological processing skills are not only responsible for literacy acquisition, but that they also play an important role in morphosyntactic abilities. A third one suggests that oral language abilities, including morphosyntax affect the acquisition of literacy skills. The latter two hypothesised relations will be tested in this study by carrying out correlation and regression analyses to investigate what type of ability contributes uniquely to another skill.

Table 6 displays the correlations between the different variables across all subjects. As shown, almost all of the variables were moderately to highly correlated except for auditory identification and discrimination and the forward version of the digit span task. As expected, word decoding and recognition correlated with phonological awareness, with the backward version of the digit span, with sensitivity to agreement and with sentence recall. Sensitivity to subject-verb agreement correlated with phonological awareness, non-word repetition, digit span, sentence recall and auditory discrimination.
Table 6. Correlations between word recognition (RWT) and decoding (PWT), agreement (AGR), phonological awareness (PHON), non-word repetition (NWR), digit span forward (DSFOR), digit span backward (DSBAC), auditory discrimination (Discrim.), auditory identification (IDENT) and sentence recall (SENT).

<table>
<thead>
<tr>
<th></th>
<th>RWT</th>
<th>PWT</th>
<th>AGR</th>
<th>Phon</th>
<th>NWR</th>
<th>DSFOR</th>
<th>DSBAC</th>
<th>Discrim</th>
<th>IDENT</th>
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<tr>
<td>3</td>
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<td>.108</td>
<td>.541**</td>
<td>.196</td>
<td>.689**</td>
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<tr>
<td>7</td>
<td>.533**</td>
<td>.465**</td>
<td>.407**</td>
<td>.462**</td>
<td>.527**</td>
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<td>.228</td>
<td>.218</td>
<td>.136</td>
<td>.155</td>
<td>.058</td>
<td>.581**</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>.371*</td>
<td>.288*</td>
<td>.598**</td>
<td>.360*</td>
<td>.651**</td>
<td>.587**</td>
<td>.586**</td>
<td>.275</td>
<td>.139</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

5.4.5.1 Predictors of word decoding ability

To examine the relative contributions of phonological awareness, verbal WM and sensitivity to subject-verb agreement to word decoding skills, a linear regression analysis has been carried out. The measures of auditory perception were not included in the regression analysis, as the calculation of correlations showed that auditory perception was not significantly related to word decoding ability.

The measures of verbal WM included the backward digit span task, the non-word repetition task and the sentence recall task. Only the results of the backward digit span task were taken, and not the results on the ‘forward’ version, as these did not correlate with the two reading tasks.

As the RWT and the PWT were highly correlated, a composite word decoding score was computed by calculating the average of the two scores.

A linear regression analysis was carried out with the composite word decoding score as the dependent variable and the results on the grammaticality judgement task, the results on the phonological awareness task, and the tasks tapping verbal WM as predictor variables. The predictor variables were entered as a block in the model. Applying this kind of data entry, significant partial coefficients of the regression analyses reflect unique
contributions of variables to word decoding. The regression analysis was done across the entire sample of children. To account for the differences among the children, and therefore to account for possible differences in the interrelationships between reading, morphosyntax and phonology, two dummy variables were constructed that calculate the effect of between-group differences (Cohen & Cohen, 1975). The analysis shows that phonological awareness, the backward version of the digit span task and sensitivity to subject-verb agreement contributed significantly to word decoding (backward digit span: \( p=0.008 \), phonological awareness: \( p=0.026 \), sensitivity to subject-verb agreement: \( p=0.019 \), non-word repetition \( p=0.91 \), sentence recall: \( p=0.23 \)).

5.4.5.2 Predictors of sensitivity to subject-verb agreement

As discussed in chapter 2 and in this chapter, auditory perception, phonological awareness and verbal WM have been hypothesised to play important roles in the process of establishing morphosyntactic relations. To examine whether these skills indeed predicted sensitivity to subject-verb agreement in this sample of children, a linear regression analysis was carried out with agreement as the dependent variable and auditory discrimination, phonological awareness, non-word repetition, forward and backward digit span and sentence recall as predictor variables as they all correlated with subject-verb agreement. The predictor variables were entered as a block in the model and the analysis was done across the entire sample of children. Comparable to the analysis above, dummy variables (reflecting membership of the group of children with developmental dyslexia and SLI) were constructed to account for the between-group differences (Cohen & Cohen, 1975).

Phonological awareness and non-word repetition proved to be significant predictors of sensitivity to subject-verb agreement, in contrast to auditory discrimination, backward digit span and sentence recall (phonological awareness: \( p=0.003 \), non-word repetition: \( p=0.008 \), auditory discrimination: \( p=0.62 \), forward digit span: \( p=0.16 \), backward digit span: \( p=0.6 \), sentence recall: \( p=0.55 \)).

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13 In order to estimate predictors to word decoding in unimpaired children, only the data set of the control children need to be used. However, this sample 'only' contains 18 children which is an insufficient number with respect to the number of variables that are examined. Therefore, dummy variables have been inserted that calculate the effect of group differences.
Several researchers have pointed to the relation between non-word repetition and language ability, in particular tense-marking (Bishop, 1999; Botting & Conti-Ramsden, 2001; Norbury et al., 2001). In their study to non-word repetition as a predictor of language and literacy, Botting & Conti-Ramsden (2001) identified children with SLI who showed intact non-word repetition. It appeared that this subgroup of their sample of SLI children (6% of the participants) performed significantly better on tense marking tasks and other language and literacy measures than children with impaired non-word repetition, suggesting that non-word repetition is a predictor of language and literacy skills. With this emphasis on the predictive role of non-word repetition in SLI, the results on the non-word repetition task and the relation with language and literacy will be inspected in more detail in our population below.

The results of this study first of all confirm the idea that non-word repetition is indeed impaired in SLI. The scores ranged from 1-8 (with a mean of 5.5), whereas the lowest score of a control child was 8. The distribution of the scores of the dyslexic children shows an overlap with those of both the SLI group and the control group. The dyslexic group average is significantly higher than the SLI group and significantly lower than the controls. Thus, non-word repetition is affected in dyslexia, but it is not as striking as it was observed in the SLI group.

A second question that arises is whether non-word repetition is solely a significant predictor of tense marking, or whether it also relates to agreement marking. As shown above, a regression analysis showed that that is indeed the case. Non-word repetition significantly predicts variance in the sensitivity to agreement marking. Looking at the data, it can be seen that, on average, the SLI children have low scores on both variables. In contrast, the controls have high scores on both tasks. The scores of dyslexic children are in between those of the SLI and control children, reflecting lower than normal scores on both non-word repetition and the agreement task.

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14 Botting & Conti-Ramsden (2001) suggest that this subgroup may either have overcome their phonological impairment, or have pragmatic difficulties which are reflections of a different deficit than typical SLI.

15 There are individual exceptions (in all three groups) to the correlation between non-word repetition and subject-verb agreement, underlining the difficulty to identify predictors that hold on an individual basis.
5.4.6 Discussion

Study 2 was carried out addressing three research questions that will now be discussed.

The first question was:

1. Is the level of sensitivity to agreement morphology of children with developmental dyslexia comparable to that of children with SLI?

The results of the grammaticality judgement task showed that the dyslexic subjects were less sensitive to subject-verb agreement relative to the controls, just like the SLI children. However, the group of SLI children was significantly outperformed by the dyslexic children. Not only did the SLI children have lower discrimination scores than the dyslexic children, but 9 of the 11 children scored at-chance level (an average A’ value of around 0.5), whereas the average A’ value of all of the dyslexic children indicated above-chance level performance. Thus, the dyslexic children resembled SLI children with respect to their sensitivity to agreement in the sense that they both experienced more difficulties than their age-matched peers, but the dyslexic children were less affected than children with SLI.

On the relation between developmental dyslexia and SLI

Now that the data have been discussed, the question remains what these can actually tell us about the relationship between developmental dyslexia and SLI. The experiments have unequivocally demonstrated that there are dyslexic children who next to their reading problems have difficulties with oral language: they are less sensitive to agreement morphology, and have phonological (processing) problems. Furthermore, there are children who, in addition to severe oral language impairment, have problems with word recognition and word decoding. Thus, the data confirm observations reported in other studies that the same symptoms are present in the different syndromes. On several tasks, including sensitivity to subject-verb agreement, non-word repetition and sentence recall the dyslexic children scored, like the children with SLI, significantly below the level of that of the control children, but better than the children with SLI.
Two hypotheses on the relationship between developmental dyslexia and SLI have been proposed: dyslexia and SLI are qualitatively different, and dyslexia and SLI are consequences of the same type of disorder and only differ in the degree of the severity of the disorder. The data acquired in this experiment certainly show, as discussed above, that the same type of deficits are present and that there is a difference in severity. In almost all instances the SLI children are outperformed by the dyslexic children, apart from the reading tasks in which the reversed pattern can be observed and the phonological awareness task and backward digit span task on which the children with SLI and dyslexia perform the same. It is however, difficult to draw firm conclusions about the exact relationship between the two syndromes based on behavioural data. Even though the data show the pattern expected if one assumes the two syndromes to be stemming from the same deficit, it is entirely possible to find this pattern of results if the symptoms of children with developmental dyslexia and SLI stem from qualitatively different deficits that are, however, strongly correlated. In that case, the symptoms and task performances are also expected to correlate, just as was observed here. Experimental techniques, other than behavioural studies, like neuro-imaging techniques and genetic research may provide more insight into the deficit(s) underlying SLI and dyslexia.

Another question that was raised is:

2. Are agreement deficits in both experimental groups related to impairments in auditory discrimination, phonological awareness and verbal working memory?

Children with developmental dyslexia and SLI were found to score lower relative to controls on tasks of phonological awareness and verbal working memory (WM) skills, except for the ‘forward’ version of the digit span task in case of the dyslexic subjects\(^{16}\). Correlations were found between the agreement task and the phonological awareness and memory tasks, with agreement correlating the strongest with non-word repetition and sentence recall. A regression analysis showed that both phonological awareness and non-word repetition predicted unique variance in sensitivity to agreement. This relation between phonological analysis, verbal WM and agreement adds to evidence from Joanisse.

\(^{16}\) The ‘forward’ version of the digit span task places a lower load on the verbal WM system compared to the ‘backward’ version, as the latter not only addresses the rehearsal system like the ‘forward’ version, but also implicates the central executive system. The difference for the dyslexic subjects between the two versions of the digit span task may reflect the nature of the limitations in the WM system.
et al. (2000), Norbury et al. (2001), and Botting & Conti-Ramsden (2001) who found that either phonological awareness was related to morphosyntactic rule formation in developmental dyslexia or that non-word repetition was related to finite verb morphology in SLI. The present results indicate that the relationships between phonological analysis, non-word repetition and finite verb morphology can be extended to a mixed population of children with SLI, developmental dyslexia and control children and also hold for agreement morphology next to tense.

As pointed out in the introduction of this study, speech perception and processing of auditory information have been put forward as key factors in developing morphosyntactic rules (Joanisse & Seidenberg, 1998; Leonard, 1989; 1998). Therefore, difficulty with the tasks tapping speech identification and discrimination was expected in children with decreased sensitivity to agreement. The correlation analyses showed auditory discrimination to correlate with sensitivity to agreement, in contrast to speech identification, which did not correlate with agreement. The discrepancy between the two speech perception tasks may lie in the fact that auditory discrimination taps verbal WM more than speech identification does. In the discrimination task, two speech sounds need to be stored in short-term memory and need to be compared in order to carry out this task successfully, next to speech perception ability. The identification task poses fewer demands on verbal WM, as only one speech sound needs to be processed. Thus, the correlation of auditory discrimination with agreement may actually reflect the verbal WM component of the task that was deployed in this study. Furthermore, this means that speech perception skills were not related to sensitivity to agreement in this population.

Does this finding imply that morphosyntactic impairments can be observed in the absence of auditory perception impairments? Such an interpretation is in line with that of Joanisse et al. (2000) who found affected tense marking in children with dyslexia who show intact speech perception. Furthermore, in this experiment, three of the eighteen control children scored at or below-chance level on the identification task, while their sensitivity to subject-verb agreement was normal. Bishop et al. (1999) also found normally developing children to have poor performance on auditory processing tasks, indicating that auditory deficits are not necessarily related to language impairment. However, it may be too rash a conclusion that absence of speech perception deficits in test situations does not implicate a relation with sensitivity to agreement. It may well be possible that the decreased sensitivity to agreement in the clinical groups stems from speech perception deficits in early childhood, which at that point interfered with morphosyntactic learning, but have now resolved and are therefore not detected at this moment of testing.
Furthermore, Bishop et al. (1999) propose that auditory processing deficits may be one of more factors involved in triggering language impairment. It may be that children who are affected in ‘only’ one variable related to language impairment (i.e. a speech perception deficit) go on to develop normal language skills, whereas other children who are faced with a combination of variables that may be detrimental to language development (Bishop et al. (1999) identify ‘genetic risk’ as one) will show language impairment.

What do the data of Study 2 mean for the theoretical explanations of SLI and developmental dyslexia? For both types of language impairment, limitations in processing capacity and delayed/disordered (for SLI) development of syntactic principles have been articulated as possible bases of language impairments. The results of Study 2 clearly indicate that children with developmental dyslexia and SLI have more difficulty with detecting agreement violations than children with normally developing language skills. Furthermore, both clinical groups also have more problems with phonological tasks, with phonological awareness and non-word repetition significantly predicting variance in agreement. These findings provide support for the processing accounts of developmental dyslexia and SLI, as these predict a link between phonological analysis and verbal WM on the one hand and morphosyntax on the other.

As sketched in the introduction, agreement markers express a relationship between the subject of a sentence and the verb. It is not hard to imagine that verbal WM is addressed in the processing of this dependency relationship. The demands of the judgement task may especially tax the verbal WM system: the number and person features of the subject need to be retained in order to be able to judge whether those of the verb match them. Could it be the case then, that the relationship between verbal WM measures and the agreement results is task-specific and does not hold for agreement marking in other situations, such as production of agreement in everyday life speech situations? It is unlikely that verbal WM is not addressed when producing subject-verb agreement, as the features of two linguistic notions (the subject and the verb) have to be linked together in order to produce the correct verb form. Samples of spontaneous speech were analysed in Study 1, which demonstrated that the production of agreement markers is also affected in dyslexia. Furthermore, De Jong (1999) reported agreement errors elicited in a production task by Dutch speaking SLI children. However, no correlations between agreement production data and verbal WM data are available, which are needed to estimate whether WM is involved in normal life speech situations in which verbs need to be marked for agreement with the subject. Thus, (subtle) impairment of agreement in children with language impairment has been demonstrated across tasks and spontaneous speech
samples. However, measures of subject-verb agreement in different test situations which can be related to measures of verbal WM are needed to provide more insight into the role of verbal WM with respect to agreement (see also Norbury et al., 2001).

Finally, the third question that was addressed in this study is:

3. What do the data tell us about the relationship between subject-verb agreement, phonological processing and word decoding/recognition skills?

The regression analysis showed that not only phonological awareness contributed uniquely to word decoding and recognition, but also that the digit span task (backward version) and sensitivity to subject-verb agreement predicted unique variance in reading aloud words/pseudo words.

How can these interrelationships between word decoding and recognition on the one hand and phonological awareness, verbal WM and subject-verb agreement on the other be explained?

As has been discussed in chapter 2, phonological awareness plays an important role when learning to read. The majority of children learns to read via linking a phoneme to a grapheme and vice versa. The ability to segment the individual phonemes of a word and to ‘understand’ the phonological make-up of a word will certainly help a child with the process of grapheme-phoneme conversion (Bryant & Bradley, 1985; Rack, 1994).

Verbal WM is involved in holding the phonological representation in storage while a child is attempting to decode it and is important for the long-term learning of grapheme to phoneme conversion rules (Gathercole & Baddeley, 1993).

Thus, phonological awareness and the backward digit span task are predictors of word decoding and recognition as they play specific roles in analysing and processing the phonological structure of words and in linking the phonemes to graphemes required for word decoding.

The regression analysis furthermore demonstrated that sensitivity to agreement also predicted word decoding and recognition. Gallagher et al. (2000), Snowling et al. (2000) and Catts et al., (1999; 2002) have suggested such a relationship between grammatical and literacy skills. They propose that good linguistic skills (both semantic and syntactic) enable a child to use the context of the words a child is trying to decode. Tunmer et al. (1987) also underline the role of syntactic skills (labelled as ‘syntactic awareness’) with respect to the development of decoding skills. They suggest that
syntactic awareness may influence the development of word decoding by allowing children to combine knowledge of the constraints of sentential context with incomplete phonological information to identify unfamiliar words correctly. Such contextual facilitation does not only help on a short-term basis (the decoding of a word within a given context), but also facilitates word decoding on a more long-term basis as with each word correctly identified, a child increases his or her knowledge of sound to letter correspondences. Furthermore, Tunmer et al. (1988) propose that contextual facilitation may be especially important for learning more complex rules, such as those whose application depends on the position of the letter in the word. For instance, learning to read irregular spelled words may be facilitated by syntactic (and semantic) awareness. Beginning readers need to learn that some grapheme combinations have more than one pronunciation (Dutch examples are -ch-: lach (/χ/) versus chocolade (/ʃ/), or the combination of –tie-: spatie (/ʦɪ/) versus vertier (/tɪ/); English translation: laugh-chocolate and space-pleasure). If a language learner actively uses the linguistic context in which the word occurs, learning of these patterns may prevent the learner from misleading erroneous learning trials. Thus, the ability to use context (both semantic and syntactic cues) helps establishing grapheme-phoneme correspondence rules. When a word has been decoded via this route often enough, combinations of graphemes will be recognised in an automatic fashion, and in a later stage the words as a whole will be recognised. Knowledge of grapheme to phoneme conversion facilitates word decoding also when words need to be read in isolation as combinations of graphemes (‘chunks’) will be recognised automatically. This also holds for reading aloud (decoding) pseudo-words: these words are made up of grapheme combinations that as a whole do not exist in the language of the child, but parts of grapheme combinations actually do occur. Decoding pseudo-words will be faster and more accurately when grapheme combinations are encountered which will be automatically recognised, in contrast to grapheme combinations that need to be converted on a grapheme by grapheme basis.

Tunmer et al. (1987; 1988) have measured syntactic skills with meta-linguistic tasks (correction of errors). The grammaticality judgement task that is used in Study 1 and 2 is also a meta-linguistic task. The question arises whether it is specifically meta-linguistic ability that facilitates letter-sound rules, or whether it is the actual ‘knowledge’ of morphosyntactic rules that plays a role. In other words, is specific meta-linguistic ability required to use contextual facilitation that helps with establishing sound-letter rules?

Bowey & Patel (1988) addressed this question. First grade children were assessed with standardised tests of general language ability (TOLD-P for an index of syntactic
proficiency and the PPVT to measure receptive vocabulary) and with a test of phonemic and grammatical meta-linguistic ability (error correction). Reading ability was assessed by a word recognition test and a comprehension test. Hierarchical multiple regression analyses were used to see whether meta-linguistic abilities make an independent contribution, next to general language ability, to word decoding and reading comprehension. When results of the TOLD-P and the PPVT were entered first in the analysis with word decoding as the dependent variable, they accounted together for 41% of the variance in word decoding ability and for 29% in reading comprehension, and the meta-linguistic abilities did not contribute any significant variation anymore. When the meta-linguistic skills were entered first, they accounted for 39% of the variance in word decoding and for 17% in reading comprehension, and the two general language ability measures did not significantly account for variance in word decoding, but they did for reading comprehension (12%). Based on these results, Bowey and Patel (1988) state that ‘there is sufficient commonality between meta-linguistic and general language ability that we cannot conclude that meta-linguistic skill constitutes an ability that emerges independently of general language ability’ (1988: 379). Thus, the observation that the results of the judgement task deployed in the current experiment contributed significantly to word decoding may also have been obtained if subject-verb agreement was measured using another experimental design.

A question related to this is whether it is specifically subject-verb agreement that contributes to word decoding, or whether it is syntactic ability in general. The present data do not provide an answer to that question; tests of other aspects of syntactic ability need to be administered in order to address that issue.

In sum, the results of the experiments in this chapter have led to the following picture of the relationships between phonological analysis and processing, sensitivity to subject-verb agreement and word decoding, see Figure 8.
Sensitivity to the structure of a phonological representation is needed to build up morphosyntactic paradigms (for tense and agreement marking). Morphosyntactic rule formation depends at least partly on structural phonological analysis as the verb stem needs to be phonologically combined with agreement/tense marking morphemes. A good storage and processing system is needed in order to keep traces of such phonological representations ‘alive’. If traces of phonological representations fade too quickly, automatisation of recognising the different verb forms will take much longer to establish. Furthermore, subject-verb agreement marking expresses the structural relationship between a verb and the subject of the sentence. This means that the number and person features of a subject need to be held in memory for accurate processing of the agreement features of the verb. In this way limited storage or processing capacity affect building up morphosyntactic paradigms.
In turn, when starting to learn to read, phonological awareness facilitates grapheme to phoneme conversion. The use of syntactic context (syntactic bootstrapping) enables a child to decode a word which in turn enhances the experiences of word decoding and provides a child with successful learning trials. This will lead to faster word recognition and to faster and more accurate decoding of words that have not been encountered before, as grapheme combinations will be recognised automatically.

5.4.7 Conclusions

The two studies presented in this chapter have shown that children with a specific reading disorder may also show problems with spoken language in the area of processing subject-verb agreement. Study 1 demonstrated that this difficulty was not related to their lack of experience with written text, relative to their age-matched peers as they were outperformed by children who had the same reading level.

In Study 2, a mixed population of children with dyslexia, SLI and normal language skills were presented with tasks measuring sensitivity to agreement, phonological (processing) skills, auditory perception and literacy development. Children with SLI demonstrated impaired performance relative to controls on all tasks apart from auditory perception, and scored significantly lower than the dyslexic children on the measure of sensitivity to agreement and the verbal WM measures, except for the backward digit span task. It became evident that phonological awareness and non-word repetition were related to sensitivity to agreement, suggesting that impaired phonological awareness and limitations in the verbal WM system underlie difficulties with subject-verb agreement in children with dyslexia and SLI. Furthermore, investigations into the determinants of deficient literacy skills revealed that not only phonological awareness and verbal short term memory, but also the results on the agreement task predicted variance in word recognition and decoding.
Appendix I: The items of the grammaticality judgement task

Subject-verb agreement violations type 1:

1. Het vrolijke meisje zing een wijsje
2. Dagobert Duck pak een dropje
3. Het lieve meisje fiets een eindje
4. Mickey Mouse vang een grote bal
5. Het stoute meisje volg een zwarte hond
6. Minnie Mouse bak een appeltaart
7. Kermit de Kikker krijg een sprookjesboek
8. Het leuke meisje duw een man om
9. Het ondeugende zusje knoei een beetje
10. Pluto de hond begraaf een dik bot

Grammatical sentences matching type 1/2 violations:

11. De lieve meid wast een trui
12. De jarige vrouw eet een taartje
13. De grote man zaagt een boom door
14. De grote jongen leest een boek
15. De dikke kok maakt een taart
16. De aardige man tekent een bloem
17. De oude vrouw breekt een kopje
18. De dikke koning rookt een pijp
19. De vrolijke jongen trapt tegen de bal
20. De aardige man bekijkt een schilderij

Subject-verb agreement violations type 2:

21. De kleine kleuter kijken naar een auto
22. De oude vrouw wassen een kopje
23. De gevaarlijke stier bijten de koe
24. De dikke man drinken een glas sinasappelsap
25. De lange vrouw krijgen een fiets
26. De kleine kleuter eten een snoepje
27. De lieve juffrouw lezen een boekje
28. De bruine vogel vliegen in de lucht
29. De knappe jongen winnen een medaille
30. De meester knippen het papier af

**Subject-verb agreement violations type 3:**

31. De kleine jongens gooit een stok in het water
32. De stoute jongens verstopt een bal
33. De wilde tijgers achtervolgt de jongens
34. De bruine caviës eet een wortel
35. De rode auto’s rijdt in de straat
36. De groene kikkers kwaakt in de vijver
37. De rode knikkers rolt over de grond
38. De lieve oppassers woont vlakbij ons
39. De moedige ridders woont in een kasteel
40. De vriendelijke kappers knipt mijn haren

**Grammatical sentences matching type 3:**

41. De kleine kabouters lopen in het bos
42. De lieve baby's liggen in de box
43. De zwarte vogels vliegen door de lucht
44. De oude ooms eten een stukje taart
45. De stoute jongens plagen het meisje
46. De dikke kikkers kwaken in het water
47. De bruine ezels lopen in het weiland
48. De zwarte pantoffels liggen onder mijn bed
49. De enge tovenaars kennen een heks
50. De tandenborstels liggen in de badkamer

**Control condition:**

51. Het kind heeft in de getennist
52. Mijn tante heeft met de gezwaaid
53. De meneer heeft in de ontbeten
54. Pluto heeft in de geblaft
55. De jongen heeft in de gespeeld
56. Het meisje heeft in de gestoeid
57. Mij moeder heeft in de gefietst
58. Willy Wortel heeft in de geknutseld
59. De jongen heeft in de gezwommen
60. Mijn oom heeft in de gevist
Appendix II: the items of the phoneme deletion task

1. (g)raf
2. (v)lo
3. kwar(t)
4. wes(p)
5. v(l)ieg
6. k(l)ok
7. (k)noei
8. (s)moel
9. mon(d)
10. pruil(t)
11. k(r)uik
12. s(t)em
13. s(l)eepe
14. (p)looi
15. har(k)
16. poet(s)
17. p(r) uik
18. s(ch)ein
19. (s)tuur
20. (k)wast
21. plon(s)
22. rech(t)
23. b(l)oes
24. s(p)el
25. (d)ruif
26. (p)rak
27. slur(f)
28. vreem(d)
29. k(w)ijt
30. t(r)ein

Appendix III: the items of the non-word repetition task

1. toes
2. juifoot
3. jeemuibooaus
4. sooteif
5. beepoetaamuuf
6. joeseewaup
7. hiepeusoefuuteem
8. waafjijsien
9. hiejeemuteip
10. fooneiwuisoetaam
11. feupaan
12. baawoovuujiezaun
13. waaduis
14. wuutaamobeejuin
15. suutaumief
16. puusoedauijien
17. jenoes
18. toopeusiewoem
19. doolieneif
Appendix IV: the items of the sentence recall task

1. Vissen zwemmen
2. Jan is blij
3. Koeien zijn groot
4. Mama werkt hard
5. An heeft een rode jas
6. De stoute hond liep achter de kat
7. Karel heeft twee poppen en een bruine teddybeer
8. Het is heel leuk om in de zomer op reis te gaan
9. Peter zou graag nieuwe laarzen en een voetbalbroekje hebben
10. Als je teveel koekjes en ijsjes eet, kan je buikpijn krijgen
11. Door de hevige regen van de voorbije nacht kwamen veel bussen te laat op school
12. Maandag gaat onze klas naar de dieren tuin, breng je boterhammen mee en zorg ervoor dat je op tijd bent
13. De koopman wil niet dat er appels in het kistje bij de fles liggen dus hij legt er druiven voor in de plaats
14. Het kleine varken wordt door de boer in de wei gezet omdat hij de stal schoon gaat maken
15. De ondeugende kat krabt het hondje dat het meisje in haar enkels bijt