Sensitivity to Subject-Verb Agreement in Children with Developmental Language Disorders

A comparison of developmental dyslexia with SLI

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1. Introduction

Developmental dyslexia refers to an impairment in reading and writing, despite average intellectual ability and normal educational opportunity. The average population risk of developmental dyslexia is around 3-10%. However, the risk of first-degree relatives of dyslexics is estimated to be 40% (Gilger et al., 1991), suggesting a genetic component to the disorder. Converging evidence suggests that the source of the reading and writing problems is in the phonological domain, even though visual deficits are also observed in developmental dyslexia (Lovegrove, 1994).

Investigations into the language development of children with dyslexia have revealed (subtle) problems in the areas of lexical-semantics and syntax, next to their phonological problems. The present study focuses on sensitivity to subject-verb agreement. Existing experimental evidence on syntactic ability in developmental dyslexia will be discussed below.

1.1 Syntactic skills in developmental dyslexia

Several researchers have studied (the development of) syntactic skills in dyslexia. Studies conducted in the eighties revealed differences between dyslexic and control children in the comprehension of relative clauses and passive sentences (Mann et al., 1984; Stein et al., 1984). Waltzman & Cairns (2000) demonstrated that dyslexic children of around 8 years old had more problems with the interpretation of pronouns in some sentence contexts (application of principle B) than normally developing children. Problems with productive and receptive (morpho-) syntactic skills were also found to be differentiating between dyslexic and normally developing children when they were between 30-48 months old (Scarborough (1990, 1991). Lyytinen and co-workers (2001) investigated grammatical development of children with an increased risk of developmental dyslexia due to their familial background in a longitudinal study. The group of at-risk children produced significantly shorter sentences at 24 months as measured by calculating the mean length of utterances (MLU) compared to a control group. In addition, the at-risk children were more impaired in inflectional verb morphology and derivational morphology at 42 months relative to control children. Joanisse et al. (2000) found the production of tense morphology to be impaired in dyslexic children of around 8 years old. Sensitivity to subject-verb agreement in dyslexic children around 8 years of age was investigated by Rispens et al. (in press[ab]). In these studies, spontaneous speech was analysed on the production of agreement morphology in addition to administering a grammaticality judgement task. The results showed that dyslexic

children made more errors with the production of agreement and that they were less able to discriminate between grammatical sentences and sentences containing subject-verb agreement violations than normally reading children.

1.2 An overlap with SLI?

The language development of children with specific language impairment (SLI) is characterised by deficits within the phonological, lexical-semantic, syntactic or pragmatic modules of language (Leonard, 1998). In addition, around 50% of the children with SLI experience problems with word recognition and decoding (McArthur et al., 2000; Catts, 1993, 1995). Furthermore, McArthur et al. (2000) found in their study that around 50% of the children with dyslexia could also be classified as having SLI. As discussed above, children with dyslexia have been found to have problems with comprehension of relative clauses, passives, pronouns and with verb morphology. The same types of problems have been demonstrated in SLI. For instance, de Jong (1999) found production of inflectional verb morphology (tense and agreement) to be impaired in Dutch children with SLI (for English and other languages, see Leonard (1998)). Van der Lely and colleagues (1996, 1997) report problems with the interpretation of pronouns and passive sentences in English speaking children with SLI. Thus, at first sight an overlap seems to exist between developmental dyslexia and SLI. Children with dyslexia experience, next to their problems with word recognition and decoding, difficulties with oral language, whereas children with SLI have in addition to their impaired spoken language development often problems with literacy skills.

An important question to consider is whether this overlap in symptoms of dyslexia and SLI implicates that the two syndromes actually stem from the same mechanism, or whether dyslexia and SLI are, in fact, two qualitatively different syndromes.

Tallal & Piercy (1973), Tallal (1980), Merzenich et al. (1996) and Tallal et al. (1996, 1997) pursue the former idea. To their minds, language and reading difficulties stem from a deficit in the perception of rapidly changing acoustic features. This impairment (known as the temporal processing deficit) will impact on the learning of speech features, and, in turn, on the learning of language. Tallal and co-workers argue that there is a developmental continuum between early language disorders and phonologically based reading disorders and that it is primarily the factor age that distinguishes developmental language impairment from reading impairment (Tallal et al., 1997). Following this hypothesis, it will be assumed that dyslexia and SLI are furthermore distinguished by the severity of the disorder. The oral language problems of children with dyslexia seem less severe than those of children with SLI. Thus, in this sense dyslexia is a ‘milder’ form of SLI.

Snowling et al. (2000) argue against the view of SLI and dyslexia being two manifestations of one underlying disorder. Instead, they propose that the literacy problems often observed in children with SLI differ qualitatively from those of children with developmental dyslexia. Phonological processing deficits lie at the heart of the word decoding problems of children with dyslexia, whereas Snowling et al. (2000) suggest that limitations of oral language ability in SLI prevent children from using linguistic context when they are decoding text which interferes with the

development of word decoding skills. Catts et al. (1999) agree with the idea that oral language skills are related to word decoding. Children who have large vocabularies or have advanced grammars learn to recognise words faster than children with small vocabularies and weak grammatical skills. Language impairments furthermore prevent a child from compensating for a phonological deficit or weak word recognition skills by using their linguistic knowledge for contextual facilitation.

In sum, there is evidence that children with SLI and dyslexia experience the same types of problems. In the present study, children with developmental dyslexia will be directly compared with children with SLI to investigate commonalities between the two syndromes.

1.3 Research questions

The present study has been conducted to address the following research questions:

1). Are children with developmental dyslexia as sensitive to subject-verb agreement as children with SLI?

2). Are word recognition and decoding skills of children with SLI comparable to those of dyslexic children?

2. Methods

2.1 Subjects

Children with developmental dyslexia

20 children with developmental dyslexia (12 boys, 8 girls; mean age 8;08) participated in this study. The children 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[1])) 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 expected reading level 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 three, the first year that they start with formal reading instruction. On average, 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

[1] 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.

children) were presented with the task 'figures'[2] (non-verbal task), 'similarities'[3] 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 I.Q.'s.

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.

Children with SLI

21 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 I.Q., measured by educational specialists as part of the review process in school, being a native speaker of Dutch and absence of any neurological deficits. There were no differences in chronological age between the group of children with SLI and developmental dyslexia.

Control children

18 Dutch children (9 boys, 9 girls, mean age 8;08) were selected to match the dyslexic children and the children with SLI on chronological age. All children had at least average reading skills, as assessed with the AVI-test, and showed normal progress in school.

2.2 Materials

Grammaticality judgement task

Grammatical and ungrammatical sentences were presented auditorily from a laptop computer (Toshiba Satellite). The correct sentences 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, sentences were presented in which a noun was missing from the Prepositional Phrase (PP); see type 4 for an example. This condition was inserted to see whether children were able to make

[2] 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.

[3] 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').

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, 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. 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/[4]. 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 vowel, rather than with a /t/ or a /d/ to prevent from co-articulation influences which would interfere with perception of the inflection morpheme; for example, *de jongen trap**t** **t**egen 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 ***t**egen*.

[4] 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.

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.

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 paper 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. 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).

2.3 Procedure and data analysis

The tasks were administered in a quiet room at school, or in a room at the dyslexia research centre spread over two sessions.

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 (2 grammatical and 1 ungrammatical sentence) 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 on one of two buttons 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.

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 and 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 and Redmond (1999) the formula as described in Linebarger et al. (1983) was used to calculate these scores: $A'=0.5 + (y-x)(1+y-x)/4y(1-x)$ 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).

The reading tasks

The RWT (Brus and 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 score was 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.

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).

3. Results

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 groups showed problems with this control condition, in contrast with 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.

The mean percentages correct on the grammaticality judgement task are displayed in Figure 1. In order to protect the data against a possible bias of accepting sentences as grammatical, the statistical analyses will be done on the A' values. Table 1 shows the mean A' values 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 ($p<0.003$).

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 1. 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 dyslexics and controls performed well above chance-level.

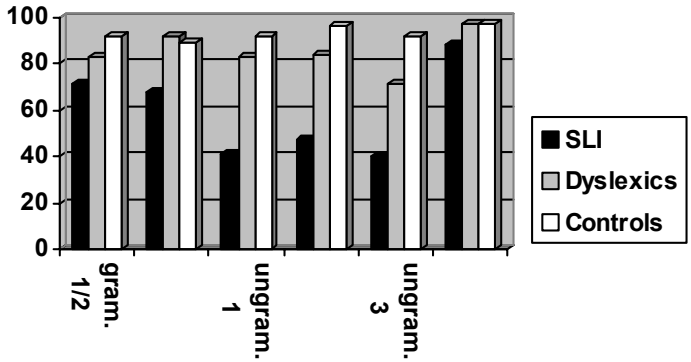

Figure 1. The mean percentages correct on the grammaticality judgement task.

Performance on the grammaticality judgement task was not 'all or nothing'. Especially the SLI children, but also the dyslexic children to a lesser extent, did not all score similarly on the task. Two SLI children demonstrated the ability to detect agreement violations, attaining overall A' values over 0.8 and two children showed 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 showed some variability in their ability to detect agreement violations, not only between the individuals, but also, like the SLI children, between the three conditions. Ten of the children scored more than 1 standard deviation below the normative mean (normative mean A' value of 0.96, SD 0.03) and eight children scored across the three conditions more than 2 standard deviations below the normative mean. 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.

Measure	**Dyslexics**	**SD**	**SLI**	**SD**	**Controls**	**SD**
A' type 1	0.89	0.08	0.60	0.15	0.96	0.04
A' type 2	0.92	0.05	0.53	0.28	0.97	0.03
A' type 3	0.88	0.12	0.55	0.25	0.95	0.06
Mean A' value	0.9	0.07	0.56	0.18	0.96	0.03
Control condition	97%	6%	88%	12%	97%	7%

Table 1. 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.

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 2 for group averages.

Real Word Reading task:

Table 2 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).

Measure	**Dyslexics**	**SD**	**SLI**	**SD**	**Controls**	**SD**
PWT	4.1[ab]	1.5	7.4[a]	3.7	12	2.7
RWT	3.1[ab]	1.5	6.1[a]	3.3	11.9	2.7

Table 2. The standard scores on the PWT and the RWT.
[a] Score significantly lower than control group
[b] Score significantly lower than SLI group

4. Discussion

Previous studies demonstrated that children with dyslexia have more problems with agreement morphology than control children (Rispens et al, in press[ab]). The main aim of the present investigation was assessing whether children with dyslexia perform similarly to children with SLI on a task tapping sensitivity to subject-verb agreement. The results show first of all that children with developmental dyslexia and SLI have more problems with discriminating between grammatical sentences and sentences containing agreement violations than normally developing children. In turn, the group of dyslexic children outperformed the children with SLI on the grammaticality judgement task. Not only made the dyslexic children less errors than the children with SLI, but the scores also indicated that the dyslexic children scored above chance-level, whereas the mean A' value of the children with SLI did not exceed chance-level.

These results show that children with dyslexia and SLI experience the same type of deficits: they are both less sensitive to agreement morphology than normally developing children. The findings fit in with the idea that dyslexia and SLI result from the same type of disorder, but that children with dyslexia are less affected than the children with SLI. Of course, linguistic skills other than subject-verb agreement need to be assessed in order to be able to draw a conclusion about the similarity between the two disorders. Nevertheless, these data add to a linguistic typology of developmental dyslexia and show that there is overlap in the pattern of performance between children with dyslexia and SLI. Another question is whether the difficulties with agreement morphology spring from the same source in dyslexia and SLI. Data on phonological abilities and verbal working memory in both populations are now being analysed in order to address that question.

The data furthermore showed intra-group differences with respect to sensitivity to agreement morphology. Half of the children in the dyslexic group scored 1 standard deviation below the normative mean, indicating that the other half scored comparable to the normally developing children. These results underline the variability with respect to language performance, as observed earlier by McArthur et al. (2000). Furthermore, 9 of the 11 children with SLI scored around chance-level, with two children demonstrating sensitivity to agreement morphology, even though to a lesser extent than the normally developing children. Again, these data suggest the need to look beyond group comparisons. More research is needed to investigate these within group differences.

The scores on the reading tasks of the children with SLI also show that there is great individual variability. Five of the eleven children scored subnormally on the pseudo-word reading task, whereas the scores of the other six children fell within the normal range. These data are, again, in line with the observations of McArthur et al. (2000) and Catts (1993, 1995) who found that around 50% of the population with SLI can also be classified as dyslexic.

In sum, children with dyslexia were found to have more problems with discriminating between grammatical sentences and sentences containing agreement violations than normally developing, which was the same for children with SLI. These children performed more poorly than the children with developmental dyslexia, supporting the idea that developmental dyslexia represents a 'mild' form of

SLI. In line with other research, it was found that half of the children with SLI scored subnormally on a word decoding task. Currently, the relation between agreement morphology, word decoding and phonological (processing) abilities is being investigated for a better understanding of the data.

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