

Chapter 7

Summary and conclusions

The experiments presented in this thesis have been undertaken to provide insight into the question whether subjects with developmental dyslexia are as sensitive to subject-verb agreement morphology as subjects without dyslexia and to investigate whether possible problems with agreement morphology are related to phonological deficits that are typically present in dyslexia. Furthermore, a comparison has been made between dyslexic children and children with SLI to investigate commonalities between these two types of language disorders and a study of electrical brain activity related to processing sentences with agreement violations and another type of syntactic violation has been carried out.

In this chapter, the main findings of the experiments will be summarised and the relations between the different data sets will be discussed.

In the study discussed in chapter 4, kindergarten children with and without a familial risk of developing dyslexia participated. The main question of this chapter was to find out whether these groups of children could be differentiated on their sensitivity to subject-verb agreement. Furthermore, measures of phonological awareness, letter knowledge and rapid naming were included as they have proven to be predictive of reading in other studies. The data presented in chapter 4 showed that the children at familial risk of developing dyslexia were indeed less able to discriminate between grammatical sentences and sentences containing agreement violations than the control subjects and that these children also scored significantly lower on phonological awareness and passive letter knowledge. When the scores were again analysed after a year of reading instruction it became clear that the children who did not show normal reading progress differed significantly on sensitivity to subject-verb agreement, letter knowledge and phonological awareness. These data thus suggest that next to earlier found predictors of reading, such as phonological awareness and letter knowledge, sensitivity to subject-verb agreement is also related to reading achievement.

Chapter 5 dealt with the question how subject-verb agreement may be related to developmental dyslexia. Three assumptions on that relation have been put forward and were addressed in this chapter.

Firstly, a difference in syntactic skills between dyslexic and non-dyslexic children may be attributed to the difference in reading experience between the two groups. It is often the case that dyslexic readers have had less exposure to print than normally reading peers, and dyslexic children have less access to high-level written language as they lag behind in reading ability. In turn, reading language in addition to hearing language may advance one's development of language skills, especially linguistic notions that are not used very often in daily speech situations. Thus, a possibly observed difference between dyslexic and non-dyslexic children may in fact stem from the consequence of dyslexia, that is, less access to written language.

The second hypothesis on syntactic deficits in dyslexia is that these originate from the same source that causes the reading problems: phonological (processing) difficulty. Two types of phonologically related impairments have been assumed to not only underlie the reading deficit, but to also be responsible for (morpho-)syntactic deficits. Limited verbal working memory (WM) capacity has been suggested to interfere with syntactic processing as the processing and transfer of linguistic input in and from the phonological processor to the syntactic parser is hampered. Segmental phonological problems may also impact on morphosyntactic abilities as the formation of an inflected verb form (combining the verb stem with an agreement/tense marker) depends to a certain extent on phonological rules.

Finally, it may be the case that, in fact, syntactic deficits are unrelated to phonological (processing) deficits that are often observed in developmental dyslexia, but that the development of the syntactic system is delayed in dyslexic children. Some researchers actually take such a delay in linguistic development to be partly responsible for the reading problems dyslexic children experience. In such a scenario, children with poor linguistic skills cannot profit from syntactic and semantic bootstrapping when they are decoding words.

These three hypotheses were investigated by means of two studies. The first one specifically addressed the first hypothesis (a difference in syntactic performance is caused by the difference in reading ability between dyslexic and non-dyslexic subjects) by comparing the performance of dyslexic children on a grammaticality judgement task to that of normally reading children matched on chronological age and to that of children

who have the same reading level as the children with dyslexia. The results showed that the dyslexic children were not only outperformed by the age-matched children, but also by the children with the same reading level, excluding the possibility that reading experience is the key factor in determining syntactic performance of dyslexic children. This finding is strengthened by the results of chapter 4 in which it was found that children already lag behind in their grammaticality judgement ability at pre-reading age.

A second study was carried out to test the possibility that problems with agreement morphology correlate with phonological (processing) difficulties. Furthermore, children with SLI also participated in this experiment to explore the relation between developmental dyslexia and SLI. Different views have been expressed on this matter. Some researchers claim that developmental dyslexia and SLI represent two manifestations of the same disorder, with developmental dyslexia being a less severe form of SLI, whereas others maintain that the syndromes differ qualitatively from each other. In both syndromes, the same types of deficits are often present: auditory perception problems, phonological (processing) difficulties, (morpho-)syntactic deficits and reading and writing problems. Developmental dyslexia is characterised by a severe disturbance in the development of written language, whereas SLI refers to a specific deficit in the development of oral language. However, problems with oral language have been signalled in developmental dyslexia, just as reading deficits in children with SLI. Like in developmental dyslexia, theoretical assumptions on the deficit underlying (morpho-)syntactic problems in SLI can be differentiated on the assumption whether there is a (developmental) problem within the syntactic system itself, or whether limitations in phonological (processing) capacity interfere with (morpho-) syntactic development. The main aims of the second study were to investigate the relation between subject-verb agreement and phonological (processing) abilities in dyslexia and SLI and to explore the pattern of performance between the two types of disorders.

A grammaticality judgement task was administered, assessing the ability to discriminate between grammatical sentences and sentences containing subject-verb agreement violations. To test phonological (processing) abilities, tasks measuring phonological awareness, digit span, non-word repetition and sentence recall were administered in addition to a speech identification and discrimination task.

The results showed that the children with SLI performed significantly more poorly than the controls on all tasks except for auditory perception and that they also scored significantly lower than the dyslexic children on the tasks tapping sensitivity to subject-verb agreement, speech discrimination, forward digit span, non-word repetition and

sentence recall (three verbal WM measures). In turn, the dyslexic children scored more poorly than the controls on the grammaticality judgment task, the RWT, the PWT, the phonological awareness measure, the digit span backward, the non-word repetition task and the sentence recall task.

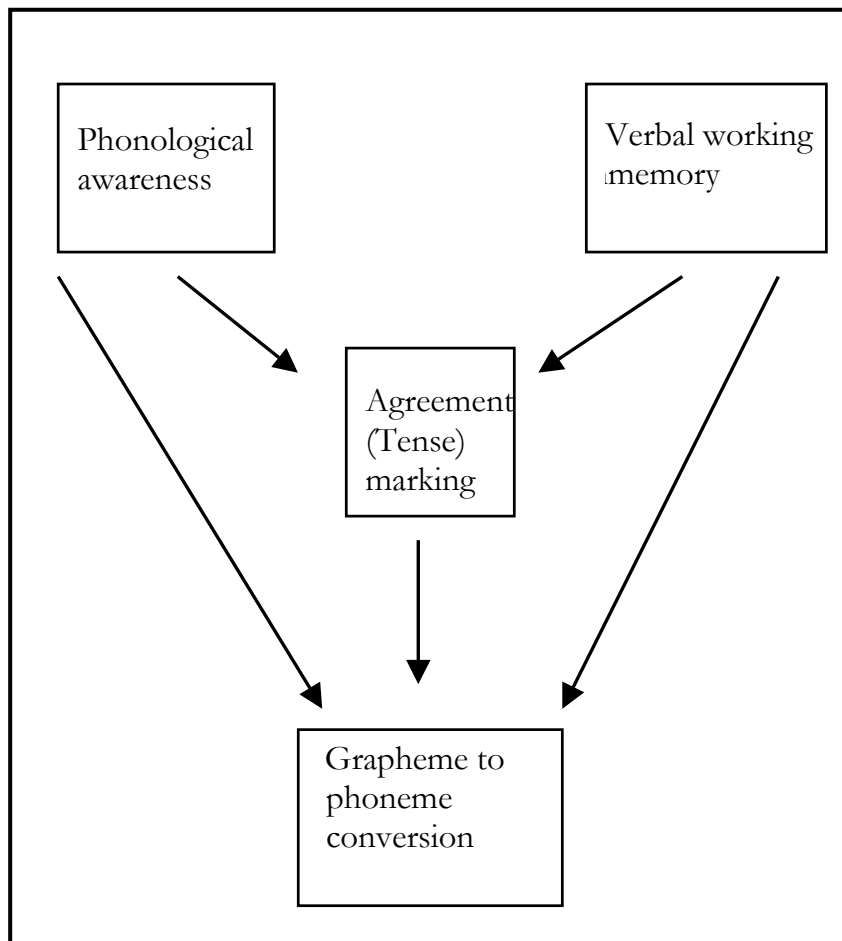
These data demonstrate the overlap in performance pattern between the dyslexic children and children with SLI: they have difficulties with the same tasks. The results support the assumption that dyslexia is a less severe form of SLI as the group of children with SLI was almost always outperformed by the dyslexic children. However, the data do not exclude the possibility that dyslexia and SLI are qualitatively different syndromes. It could be the case that, for instance, there are two mechanisms involved in the two syndromes, but that these two mechanisms are highly correlated so that the same type of symptoms show up in the behaviour of children with dyslexia and SLI. Research that not only focuses on overt behaviour, but rather draws on a genetic or neurophysiological typology of developmental dyslexia and SLI seems more promising with respect to that issue.

Combining the data obtained in chapters 4 and 5, the following picture emerges. Kindergarten children with a familial risk of developing dyslexia, and school-going children with established dyslexia are less sensitive to subject-verb agreement morphology compared to their normally developing peers. The findings that this difference in sensitivity to agreement morphology already surfaces at pre-reading age, and that dyslexic children have poorer judgement ability than children matched on their reading level do not support the possibility that this difference in sensitivity to subject-verb agreement stems from the difference in reading experience between dyslexic and non-dyslexic children.

In both subject groups, performance on phonological tasks, including measures of letter knowledge (kindergarten children), phonological awareness (kindergarten and school-going children) and verbal WM (school-going children) correlated highly with subject-verb agreement. A regression analysis, performed on the data of the mixed population of school-going children with dyslexia, the children with SLI and control children, showed that phonological awareness and non-word repetition (reflecting verbal WM) predicted unique variance in sensitivity to subject-verb agreement. This finding agrees with the hypothesis that phonological awareness and verbal WM are skills that are related to morphosyntactic performance, in this case specifically agreement marking, and suggests that difficulty with subject-verb agreement stems from deficits in these skills, rather than from an impairment or a delay in the development of the syntactic system.

Another question that was addressed in these chapters was whether sensitivity to agreement morphology is related to reading achievement next to phonological skills. The results in both chapters 4 and 5 show that this is indeed the case. The kindergarten children who did not show normal development of reading skills after one year of reading instruction scored significantly more poorly than normally developing children on tasks tapping sensitivity to agreement morphology, phonological awareness and letter knowledge at kindergarten age. The results discussed in chapter 5 show the same profile. The reading scores of the dyslexic children, children with SLI and control children were correlated with phonological awareness, agreement morphology, the backward version of the digit span task and sentence recall. To determine the specific relations between these skills, a regression analysis was carried out. It turned out that phonological awareness, the backward version of the digit span task (reflecting verbal WM) and subject-verb agreement contributed significantly to word decoding.

These data have been the basis for the following proposal of the relationships between phonological awareness, verbal WM and word recognition and decoding:



The model shows that marking for subject-verb agreement is related to phonological awareness. As discussed in chapters 2 and 5, it has been put forward by Joanisse et al. (2000) that combining the verb stem with a morpheme is partly a phonologically based rule system. Verbal WM is also important for this process as the phonological representation of a verb form needs to be maintained properly. Failure of the (temporary) storage of a phonological representation will thus result in a degraded form of that phonological representation, which interferes with building up a stable inflectional paradigm. Furthermore, verbal WM is addressed in a different way when marking a verb for person and number of the subject. Since these properties of the subject are reflected in the verb form, it is necessary that these features need to be kept activated long enough for the subject to match with the verb.

In turn, subject-verb agreement contributes to word-decoding, as the regression analysis showed. Several researchers have addressed this issue and suggest that the success of word decoding is partly dependent on the ability to make use of the linguistic context in which a word occurs. Syntactic bootstrapping (i.e. recognising a word on the basis of its structural context) will provide a child with successful learning trials. This will advance not only recognition of words, but will also promote more general decoding skills as certain grapheme combinations will be recognised automatically.

Phonological awareness and verbal WM proved to be important predictors of word decoding, a finding that was expected based on the results of many studies to predictors of reading success. Decoding of words involves linking graphemes to the phonemes of a word; a skill that thus requires knowledge of the internal phonological structure of a word. Furthermore, verbal WM is involved in the long term learning of the grapheme to phoneme mapping rules that are crucial in the process of literacy acquisition. In addition, verbal WM is necessary for the temporary storage of phonemes of a word that a child is trying to identify by applying grapheme to phoneme rules.

In chapter 6, sensitivity to subject-verb agreement in spoken language was addressed again, but now a different technique was used. In an ERP study the presence and properties of the P600 component in adults with and without developmental dyslexia were investigated, in addition to the ELAN component which was elicited by presenting subjects phrase-structure violations. It turned out that the ELAN component of the dyslexic subjects did not differ in strength and distribution, but that the peak latency was earlier for them compared with the control subjects. This in contrast to the P600 component that tended to peak later in the posterior region of the left hemisphere in the dyslexic group opposed to the controls. Other differences were also found: sentences that

contained a plural subject did not trigger a P600 component in the dyslexic subjects, just like the phrase-structure violations. The controls did show a P600 component in response to both sentence types, but the effect was less robust than found for the other two subject-verb agreement conditions (with a singular subject). The observation that the dyslexic group did not show a P600 in the sentences containing plural subjects suggests that in these subjects linguistic complexity affects sentence processing more than in control subjects. Furthermore, the distribution of the P600 component in the dyslexic subjects was also more restricted to the right hemisphere in comparison with the controls.

Combining the data of the ELAN component and the P600, it can be concluded that automatic parsing of word category information is unaffected in dyslexia and occurs even faster, but that the more controlled process of sentence repair tends to be slower compared to normally reading subjects. These data fit in with results showing delayed lexical-semantic processing, indicated by an N400 with a longer latency for dyslexic subjects. Abnormal speech processing has been hypothesised to delay access to the mental lexicon. Such a delay may not only slow down lexical-semantic processing, but may also have an effect on syntactic repair, as this is partly dependent on lexical-semantic information, in contrast to processing word category information. Neurobiological differences between dyslexic and normal readers may underlie these pre-syntactic processing difficulties.

In this experiment not only electrical activity in response to subject-verb agreement violations was measured, but also the ability to judge these sentences on their grammaticality, comparable to the subjects in chapters 4 and 5. The dyslexic adults turned out to be capable of discriminating between grammatical and ungrammatical sentences, reflected by the high scores on the judgement task. Combining the data of the three dyslexic subject groups (children at familial risk for developing dyslexia, school going dyslexic children and dyslexic adults) for a cross-sectional comparison, the picture emerges that the observed difference between dyslexic children (and children at-risk of dyslexia) and control children in sensitivity to subject-verb agreement disappears with age. There are different ways these data can be interpreted. Firstly, they may suggest that the development of agreement morphology is delayed in dyslexia and that individuals with dyslexia catch up with control subjects after some years. It is interesting to investigate, with the results of chapters 4 and 5 in mind, whether the 'recovery' of dyslexic subjects correlates with an improvement of phonological awareness and verbal WM. However, the suggestion that development of agreement morphology is delayed may be incorrect as the dyslexic adults performed, like the controls, at-ceiling level, possibly obscuring a

difference between the two groups. That there is a difference between the two groups with respect to processing subject-verb agreement information is shown by the ERP data.

In sum, the main findings of this thesis are that dyslexic children are less sensitive to subject-verb agreement morphology than normally reading children. This was also observed in children with SLI. The difference in processing agreement morphology between dyslexic children and children with SLI on the one hand and control subjects on the other was found to be related to decreased phonological awareness and limitations in verbal WM capacity in the dyslexic children and children with SLI. A neurophysiological investigation into processing of agreement violations showed that although the overt linguistic behaviour was the same for dyslexic and non-dyslexic subjects (grammaticality judgement ability), the properties of the ELAN and P600 component differed subtly.