Word-recognition processes in normal and dyslexic readers

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Chapter 7

General discussion

The main aim of the present thesis was to find possible explanations for the slow and laborious word recognition that is commonly observed in dyslexic readers. To address this issue, several experiments were conducted, all aiming to identify proximal causes that might differentiate the dyslexic from the normal reading system. The majority of the studies (Chapters 2 to 5) focused on (differences in) sublexical processing, dealing with topics like the use and size of functional units of print. Finally, the study presented in Chapter 6 examined differences in lexical processing between normal and dyslexic readers. Below, the main outcomes of the present thesis will be summarized, subsequently the implications of these findings will be discussed.

7.1 Review of the main findings

Following the outline of the final section of Chapter 1, I will start by summarizing the findings on sublexical processing. Next the results of the study on lexical processing will be presented.

7.1.1 Sublexical processes in word recognition: Which are the functional units of print?

The first study (Chapter 2), focused on the use of sublexical clusters in normal and dyslexic readers. The use of three different clusters was examined, namely the use of consonant clusters (e.g., st in stop), rimes (e.g., op in stop) and digraphs (e.g., ou in soup). A segmentation paradigm was used to investigate whether the distortion of a target cluster (e.g., s#top) resulted in a larger slowdown in naming and lexical decision speed than in a condition in which all clusters were left intact (e.g., st#op). In addition, it was examined whether these segmentation effects were different for normal and dyslexic readers. If dyslexic readers make less use
of sublexical clusters in word recognition, then the segmentation of a consonantal onset or rime cluster should have less impact on their naming and lexical decision speed as compared to normal readers. However, normal and dyslexic children were equally hampered by the distortion of a word or pseudoword in general and neither of the groups was found to be more severely hampered when a consonantal or rime cluster was distorted as compared to a segmentation condition leaving all clusters intact. On the basis of the results obtained with this specific visual-segmentation paradigm, it was therefore concluded that sublexical clusters like onset clusters and rimes are no functional units of print in the word recognition of children learning to read in a language with a transparent orthography like Dutch. Therefore, and to return to the main question of the present thesis, the slow reading speed of dyslexic readers does not seem to be a direct consequence of less use of consonantal onset clusters and rimes.

However, the visual distortion of a digraph unit (e.g., so#up) did cause an additional slowdown in the word-recognition speed of both normal and dyslexic readers. This effect appeared to be equally strong for the normal and dyslexic readers, suggesting that both groups treat digraphs as functional units in reading and are equally proficient in doing so. However, in the same study it was also found that the difference in reading speed for words with and without digraphs (e.g., stop vs. stoep [pavement]) was larger for the dyslexic children than for the normal readers. It was therefore tentatively concluded that dyslexic children do not seem to have difficulties with the initial perceptual processing of a digraph. However, problems do seem to arise when the correct sound (phoneme) has to be linked to the visually parsed grapheme. To further investigate and possibly validate these conclusions two additional studies were conducted. The study in Chapter 3 elaborated on differences in the earlier, perceptual, processing of digraphs, whereas the study in Chapter 4 examined differences in the naming of words and pseudowords with and without digraphs, hence focusing on possible difficulties in linking the phoneme of a digraph to its two constituent letters.

For the study in Chapter 3, a letter-detection paradigm was used to further examine the processing of a digraph as a perceptual unit in the normal and dyslexic reading system. The rationale behind the letter-detection paradigm is that, if a letter cluster is treated as a functional unit in reading, then the detection speed of a separate letter in such a cluster (e.g., the o in soup) will be slower than the detection speed of a letter that does not belong to a cluster (e.g., the o in soft). Indeed, both normal and dyslexic children were found to be slower in detecting letters embedded in digraphs. Interestingly, dyslexic readers were equally hampered as normal readers. To conclude, this study provided additional evidence that dyslexic readers do not have problems in processing digraph units as perceptual units. Apparently, this particular early visual processing aspect of word recognition cannot account for the differences in reading speed between normal and dyslexic readers.

As there were no apparent differences in the earlier processing of digraphs,
the research focus was shifted towards a later step in the word-recognition process, namely the linking of the phoneme to the digraph unit. In addition, the assumption that digraphs are visually parsed as perceptual units before they are mapped onto their corresponding phonemes is also of relevance to the nature of the Length effect. As described earlier, the Length effect refers to the finding that longer words and pseudowords are read more slowly than shorter ones. If digraphs are treated as perceptual units, then the length effect should be based on grapheme length instead of letter length. In Chapter 4, a study was presented aiming to disentangle such effects of length and digraph presence. Normal, beginning and dyslexic readers completed a word and pseudoword reading task consisting of items varying in length (3 to 5 letters) and digraph presence. In line with previous studies, it was found that the dyslexic and younger readers showed stronger length effects than the normal readers. Interestingly, however, these length effects indeed seemed to be based on grapheme length, and not on letter length. This implies that children decode words and pseudowords grapheme by grapheme rather than letter by letter and provides further support for the assumption that graphemes, and therefore also digraphs, are the functional units of print.

In addition, digraph presence caused an extra delay on top of the grapheme-length effect in all reading groups, but only in pseudoword naming. Interestingly, this effect was stronger in the dyslexic and beginning than in the normal readers. Hence, it was concluded that dyslexic children do experience difficulties in mapping phonemes onto the corresponding digraphs, explaining a small part of their slow and laborious reading. The effect was only found for unfamiliar (pseudo)words, suggesting that the effect pertains to sublexical processing and is no longer relevant when the reader has the opportunity to use lexical knowledge. The additional effect of a digraph on top of the grapheme length effect in the dyslexic and younger readers might be caused by a sublexical frequency effect. In other words, digraphs might not be as familiar to the dyslexic and younger reading system as to the normal reading system and that this frequency effect slows down the grapheme-to-phoneme mapping process in these groups.

The series of studies on sublexical processing was concluded with a training study aiming to improve the reading speed of poor grade-2 readers (Chapter 5). The training consisted of eight sessions in which four consonantal onset clusters were explicitly taught as blended units. One of the important rationales behind this approach was that still, a potential alternative explanation for the finding that the children in the first study (Chapter 2) only seemed to use digraphs, and not consonantal onset clusters and rimes, had to be ruled out. Specifically, it might have been the case that consonant clusters are not used as functional units in reading because they are not explicitly taught as units in Dutch education. One way to rule out this explanation is by training children to use consonantal onset clusters as functional units in reading. Therefore, 99 poor readers were selected and divided among three training conditions: a cluster-training condition, a letter-training con-
dition and a no-training control condition. It was found that, although the children of the cluster-training condition made significantly more progress on the rapid naming of the trained consonantal onset clusters than the other two training conditions, their increase in word-recognition speed was not superior to that of the letter-training condition.

7.1.2 Lexical processes in word recognition: Sensitivity to neighbourhood size and the presence of high-frequent neighbours

Chapter 6 focused on lexical processing in normal and dyslexic readers. Sensitivity to orthographic neighbourhood size was used as a marker effect. In line with the study in Chapter 4, word and pseudoword naming tasks were presented to dyslexic grade-4, normal grade-4 and beginning grade-2 readers. In contrast to the predictions, it was found that the dyslexic readers showed similar sensitivity to orthographic neighbourhood size as the normal readers, suggesting intact lexical processing. More specifically, all groups responded less accurately and more slowly to pseudowords from a low neighbourhood size and equally fast to words from a low and high neighbourhood size. There were no differences between the normal and dyslexic readers.

However, it was also found that all reading groups made more errors in words from a large neighbourhood size than in words from a small one. Post-hoc analyses showed that this unexpected result was due to a confound effect of the presence of a high-frequent neighbour. To further examine this effect, it was investigated whether the presence of such high-frequent neighbours influenced the reading speed and accuracy of the normal and dyslexic readers equally. Interestingly, and in contrast to the normal grade-4 readers, it was found that the naming speed of the dyslexic readers slowed down significantly if a word had a high-frequent neighbour. These results suggest that the orthographic representations of dyslexic children are less strongly specified or insufficiently distinct from similar candidates in the mental lexicon. However, the beginning readers were also hampered by the presence of a high-frequent neighbour and this effect was as strong as in the dyslexic group. In Section 7.2.2, I will further elaborate on the absence of differences between the dyslexic and beginning readers.

7.2 Implications

The results of the current thesis are of both theoretical and practical importance. I will start this section with the implications for theories of reading. Subsequently, I will focus more specifically on what the results of the present thesis teach us about the nature of the dyslexic reading system. Finally, the significance of reading interventions focusing on enhancing the use of larger letter units will be discussed.
7.2. IMPLICATIONS

7.2.1 Implication for theories of reading

Below, I will elaborate on the implications for theories of reading. I will start by discussing the implications for theories on reading development. Next, implications for computational models of skilled reading will be addressed.

Developmental theories

In Chapter 1, I raised the issue that current theories on reading development are not sufficiently specific in defining the processes underlying the development of automatic word recognition. In addition, these theories do not explicitly describe differences in normal and dyslexic-reading development. Progress in the understanding of the development of both the normal and dyslexic reading system can only be obtained by more specific and explicit theories, defining (falsifiable) hypotheses regarding the normal and dyslexic reading development on the one hand and well conducted experiments aiming to test these hypotheses on the other hand. Based on the results of the current thesis, at least two aspects of Ehri’s phase theory and the self-teaching hypothesis (Share, 1995) can be more strongly defined.

First, the different phases in Ehri’s theory specifically focus on the formation of associations between orthography and phonology. However, the results of several studies in the present thesis underline that the visual-parsing process, occurring before phonemes are mapped onto the corresponding graphemes, is a separate and important aspect of the word-recognition process (Chapters 2 and 3). Interestingly, in both normal and dyslexic children learning to read in Dutch, this early visual parsing does not pertain to sublexical clusters like consonantal onset clusters and rimes. However, it does occur in the case of multiletter graphemes, like digraphs, and the dyslexic reading system does not seem to deviate from the normal reading system in this respect. In contrast, when it comes to mapping the digraphs onto their corresponding phonemes (Chapter 4), the dyslexic readers do seem to be hampered. All in all, it can be concluded that children, at least the ones learning to read in a language with a transparent orthography like Dutch, do learn to use digraphs as functional units. In addition, this process, that is, the grapheme-to-phoneme mapping, seems to be delayed in dyslexic readers. In contrast, letter clusters, like onset clusters and rimes, are not visually parsed and it will be therefore unlikely that they are used as functional units as is postulated to happen in the consolidated phase of Ehri’s theory (Chapter 2). Even during a letter-cluster training (Chapter 5), in which the blended sound of consonantal onset clusters was explicitly linked to the two letters, such associations could not be established for word reading. As all studies in the current thesis were conducted with monosyllabic words, additional research is needed to determine whether children do learn to use larger letter clusters like syllables and morphemes and whether normal and dyslexic readers differ in this respect (see also Section 7.3). Verhoeven, Schreuder
and Baayen (2003) already demonstrated that normal reading Dutch children are able to identify morphemes within two-syllable words and that they are also able to subsequently activate the corresponding pronunciations of these units.

Secondly, in the self-teaching hypothesis, phonological recoding is defined very broadly as an “umbrella term for the process of print to sound conversion by whatever means this is accomplished” (Share, 2008, page 35). The results of the current thesis add that this process probably occurs grapheme by grapheme (and not letter by letter) in both normal and dyslexic children (Chapter 4). However, as both normal and dyslexic children also displayed sensitivity to orthographic neighbourhood size for pseudowords (Chapter 6), it can be concluded that phonological recoding of unfamiliar words also depends on more parallel-processing strategies like reading by analogy. In other words, children not only seem to re-code unfamiliar words grapheme by grapheme, but also by using their overlap with other, already familiar words.

Regarding differences in phonological recoding between normal and dyslexic readers, previous findings (Martens, 2006; Martens & de Jong, 2006; Spinelli et al., 2005; Ziegler et al., 2003; Zoccolotti et al., 2005) and the results of the several studies in the current thesis suggest that dyslexic children, learning to read in transparent orthographies like Dutch, German and Italian, are only marginally impaired in correctly decoding words and pseudowords, as evidenced by their relatively high accuracy scores. Their main problem seems to lie in the eventual build up of orthographic knowledge, allowing them to automatically recognize words and free them from the more laborious grapheme-by-grapheme decoding process. As described in Section 7.1.2, the results from Chapter 6 suggest that the orthographic representations of dyslexic children are less strongly specified or insufficiently distinct from similar candidates in the mental lexicon. I will further elaborate on this issue in the third paragraph of Section 7.2.2.

Models of skilled reading

In the discussion sections of Chapters 2 to 6, it has already been described how the separate results of each study fit into the predictions of computational models of skilled reading. In these studies, different paradigms were used to investigate sublexical and lexical processes. In this section, I will try to merge the outcomes of the separate studies in order to provide a joint picture of the implications of the current thesis for models of skilled reading.

In the General Introduction, computational models of skilled reading (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Perry, Ziegler, & Zorzi, 2007) were introduced as a framework for studying word-recognition processes in normal and dyslexic readers. As the majority of the studies of the current thesis focused on sublexical processing, I will begin by elaborating on what the results of the current thesis teach us about the functioning of the sublexical route. Since
only the study presented in Chapter 6 focused on lexical processing and as the implications for the functioning of the lexical route are so intertwined with the issue of differences between the normal and dyslexic reading system, this topic will be reserved for the third paragraph of Section 7.2.2, which elaborates on the functioning of the lexical route in the dyslexic reading system.

One of the main questions regarding sublexical processing concerned the size and use of units below the (monosyllabic) word level. Based on the results of the present thesis, it can be concluded that, for children learning to read in a transparent language like Dutch, graphemes appear to be the functional, sublexical units of print. Moreover, normal reading and dyslexic children do not seem to differ in this respect (see Section 7.2.2). This conclusion is based on the results of studies using a visual-segmentation paradigm (Chapter 2), a visual-letter-detection paradigm (Chapter 3) and naming tasks (Chapter 4). The results of all these studies provide evidence that words and pseudowords are visually parsed into graphemes (and therefore also digraphs) before the grapheme-phoneme correspondence rules are applied. This finding is in line with the presence of a graphemic buffer in the sublexical route, as postulated by the CDP+ model (Perry et al., 2007), but not with the assumption of the DRC model (Coltheart et al., 2001) that the sublexical route operates letter-by-letter.

In contrast to graphemes, larger letter clusters below the word level like consonantal onset clusters and rimes do not seem to be used as functional units in word recognition, neither in dyslexic nor in normal readers. The results of Chapter 2 showed that visual distortion of such units did not cause an additional delay, suggesting that monosyllabic words are not visually parsed into (consonantal) onset clusters and rimes. However, it might still be the case that children do use larger letter clusters in reading, but that the formation of these clusters occurs at a later stage in the word-recognition process, after the visual parsing has taken place, for instance when the graphemes are matched to the corresponding phonemes. The latter is also postulated by some single-route, or connectionist models of reading in which sublexical units arise as an emergent property of the learning of a distributed network (e.g., Harm & Seidenberg, 1999). Therefore, in the intervention study described in Chapter 5, effort was taken to establish such connections by explicitly training poor grade-2 readers to pronounce and treat consonantal clusters as blended units. However, this intervention did not result in superior improvement of their word-recognition speed as compared to poor readers who trained the separate letters of the cluster. Again, these results suggest that larger letter clusters, like consonantal onset clusters, are not used as functional units of print.

7.2.2 The dyslexic reading system

The main aim of the present thesis was to find explanations for the slow and laborious word recognition of dyslexic readers. To this end several word-recognition
processes were examined in both normal and dyslexic children. This section starts with a short description of the participants. Next, similarities and differences in respectively sublexical and lexical processing in the dyslexic and normal reading system will be discussed. Finally, a few additional remarks on the findings regarding the dyslexic reading system will be given.

Participants

In order to pinpoint differences in word-recognition processes in the normal and dyslexic reading system, both normal and dyslexic readers were included in the various experimental studies of the current thesis. All dyslexic children had received about 3.5 years of reading instruction (grade 4) and had a reading lag of at least 1.5 years, meaning that they were reading on grade-2 level. In the studies described in Chapters 2 and 3, the dyslexic children were matched to normal reading, chronological age control children from grade 4. For the studies in Chapters 4 and 6 a more elaborate design was used. In these studies the dyslexic readers were not only matched to chronological age controls, but also to reading age controls (beginning readers from grade 2).

Sublexical processing

As mentioned in Section 7.1.1, it is very important to distinguish between earlier visual processing and later processes in which the graphemes are mapped onto their corresponding phonemes. The results of several studies in the current thesis strongly suggest that the problem of dyslexic readers is not located in the early visual-parsing process. These findings are in line with recent findings of Hawelka and Wimmer (2008), who also found that dyslexic and normal readers performed equally well when a task is purely visual, that is, when the mapping of letters, or graphemes, to sound is not required (see also Chapter 3).

In addition to normal visual-grapheme parsing, there were no differences between the dyslexic and normal readers in terms of the use of consonantal onset clusters and rimes (Chapter 2). In sum, it can be concluded that the dyslexic reading system equals the normal reading system in terms of the (lack of) use of sublexical clusters and that there are no deficits in the early visual-parsing process. Hence, these factors can be ruled out as proximal causes of the slow and laborious reading of dyslexic readers.

However, performance differences between the normal and dyslexic readers were observed in a task requiring the mapping of digraphs onto the corresponding phonemes in reading unfamiliar words (Chapter 4). Apparently, the difficulties dyslexic readers experience in reading novel words with digraphs, is situated in the process of linking graphemes to their corresponding phonemes and not in earlier perceptual processes.
Lexical processing

In line with the results of previous findings (Martens, 2006; Martens & de Jong, 2006; Spinelli et al., 2005; Ziegler et al., 2003), dyslexic readers showed stronger Length effects than the normal reading grade-4 children. As already described in the General Introduction, such enlarged Length effects in dyslexic readers are commonly interpreted as an over-reliance on sublexical processing. A number of researchers have raised the possibility that such over-reliance might be a direct consequence of specific deficits in the lexical route (Barca, Burani, Di Filippo, & Zoccolotti, 2006; Coltheart et al., 2001). In order to test this hypothesis, several studies were conducted to examine whether normal and dyslexic readers respond differently to lexical processing markers like sensitivity to word frequency (Barca et al., 2006), sensitivity to body neighbourhood size (Ziegler et al., 2003) and word superiority effects (Ziegler et al., 2008). However, to date, no evidence has been found showing that dyslexic readers respond differently to such markers as compared with normal readers.

Therefore, the result that the dyslexic readers were equally affected by orthographic neighbourhood size as the normal reading grade-4 children did not come as a surprise. However, the dyslexic readers did show stronger sensitivity to the presence of a high-frequent neighbour than the normal reading children, indicating a deficit in lexical processing. Interestingly, this deficit seems to pertain to the specific ability to distinguish among highly similar orthographic representations. Recently, Bergmann and Wimmer (2008) also demonstrated that dyslexic readers show specific impairments in their performance on an orthographic lexical decision task. Just like reading words with high-frequent neighbours, this task required the normal and dyslexic children to focus on minimal differences between possible orthographic forms (e.g., taxi versus taksi). In sum, these findings suggest that the dyslexic reading system is specifically impaired in distinguishing among minimal differences between orthographic representations (see also Messbauer, 2005). This impairment is probably a direct consequence of a less finely tuned orthographic lexicon (Castles, Davis, Cavalot, & Forster, 2007) or less well-specified orthographic representations (Perfetti, 1992).

Comments on the findings regarding the dyslexic reading system

Although specific deficits in word-recognition processes of dyslexic readers were demonstrated (Chapter 4 and 6), three remarks need to be made. First, it has now been well documented that dyslexic children are stuck in a more laborious sublexical decoding strategy. In contrast to normal developing readers, they fail to progress towards using more efficient lexical word-recognition strategies. However, the finding that the presence of a high-frequent neighbour and the mapping of digraphs onto the correct phonemes in unfamiliar words slow down the word-
recognition speed of dyslexic readers can only account for a minor part of the reading-speed problem. In other words, these underlying causes are interesting, but still insufficient to account for the striking word-recognition speed problems that are already evident on the simplest three letter words and pseudowords like cat and caf (Chapter 4).

Secondly, it should be noted that all the differences in word-recognition processes between the normal and dyslexic readers described so far, were absent in the comparison between the dyslexic and beginning readers. Therefore, the more pronounced Length and Lexicality effects, the difficulties in attaching the phoneme to a digraph and the suffering from the presence of a high-frequent neighbour all seem to reflect a developmental lag instead of a specific problem in the dyslexic reading system. Such a lack of differences in response pattern between normal beginning readers and dyslexic children is in line with the results of previous studies conducted in transparent languages like Italian (Barca et al., 2006; Spinelli et al., 2005; Zoccolotti et al., 1999) and Dutch (Martens, 2006).

However, in the study of Chapter 4, specific differences between the beginning grade-2 and dyslexic grade-4 readers in the extent of variability in word-reading speed were found. Thus far, studies comparing word-recognition performance in normal and dyslexic readers have mainly been concerned with mean differences in reading speed and accuracy. However, it has been well established that the reading performance of dyslexics is much more variable than that of normal readers. Surprisingly, however, this larger variability in dyslexic readers has never been explicitly examined or modelled before.

As dyslexic children respond more strongly to word characteristics such as word length, there will automatically be more variability in their word-reading speed of a set of words of varying length. However, the question remains whether these differences in variability are fully a function of the response of dyslexic children to longer and more complex words, or whether their reading is already more variable when reading very easy three-letter words like cat. As expected, the word-recognition performance was more variable in dyslexic and beginning readers than in normal readers. Most importantly, however, the word-recognition performance of dyslexic readers was also found to be more variable than that of beginning readers. Interestingly, the differences were largest for the simplest, three-letter words. It is an important question how these differences in variability should be explained. In the discussion of Chapter 4, it was argued that it might reflect instability in the retrieval of orthographic knowledge (see also Perfetti, 2007).

Finally, it should be stressed that all studies were conducted with children learning to read in Dutch, a language with a relatively transparent orthography. Some results, especially concerning the use of the rime as a functional unit and the influence of neighbour words may be different in children learning to read in a language with an inconsistent orthography like English. Because of the inconsistency of the English orthography, the reading system of English readers is
predicted to be tuned to the use of units of larger grain sizes (Treiman, Mullennix, Bijeljac-Babic, & Richmond-Welty, 1995; Ziegler & Goswami, 2005) as the use of such units might help them to resolve the inconsistency of words. Compare for instance words like steak and steam. In both cases the final consonant is needed to resolve the inconsistency of the digraph unit. In other words, the whole rime has to be taken into account to properly decode the word. Note that this contrasts to the Dutch orthography, in which all digraphs are always pronounced the same. In a similar vein the inconsistency of the English orthography puts an additional dimension on top of the effects of neighbourhood size and neighbourhood frequency effects. In contrast to Dutch, in English orthographic N-size effects cannot be interpreted without taking consistency effects into account. The magnitude of the consistency effect for a given word is the weighted outcome of the summed frequency of friends and enemies of the target word (Jared, McRae, & Seidenberg, 1990). A friend is a word (e.g., lint) that has the same pronunciation as the target word (e.g., mint) whereas an enemy is pronounced differently (e.g., pint). Friends and enemies are both orthographic neighbours of the target word. However, whereas friends have a facilitatory effect on word recognition, enemies will inhibit the recognition process. Therefore, in order to properly investigate differences in sensitivity to orthographic neighbourhood size effects in children learning to read in English, future studies must take this additional consistency dimension into account.

### 7.2.3 Interventions

Considering the results of Chapters 2 and 5 and previous studies (Das-Smaal, Klapwijk, & van der Leij, 1996; Hintikka, Landerl, Aro, & Lyytinen, 2008; Hue-mer, Landerl, Aro, & Lyytinen, 2008; Levy, 2001; Thaler, Ebner, Wimmer, & Landerl, 2004; van Daal, Reitsma, & van der Leij, 1994), it is tenable to draw the strong conclusion that stimulating the use of sub-syllabic units is not a fruitful way to increase word-reading speed in children learning to read in languages with a transparent orthography. Put differently, the results of these studies indicate that the use of sub-syllabic units does not seem to be the causal mechanism behind the development of word recognition speed in transparent orthographies.

Besides this more general conclusion regarding the effectiveness of stimulating the use of sublexical clusters in order to improve reading speed, the results of the current thesis also seem to have implications for a more specific intervention technique, namely for the effect of so-called word family lists. Word family lists are a popular educational method in Dutch and English classrooms. Word family lists consist of words that are grouped by, for instance, onset cluster (stop, step, stuff, still) or rime (ban, fan, pan, ran). One of the assumptions underlying this practice is that children will implicitly learn to use the blocked clusters and that this will help them to read novel words with the same clusters. However, Reitsma
(1988) did not find any differences in word-recognition speed gains between children who practiced with random and children who practiced with structured word lists. More recently, Poole and Levy (2007) even found higher transfer effects in terms of accuracy when children were required to read words in random as compared to structured lists. Apparently, if children are offered training materials organised in such a way as to make multiletter orthographic patterns obvious, they are less likely to form strong representations of those emphasized patterns. One way to explain this finding is that children do not have to put in much effort to decode words in a word family list as compared to a random list, since the overlap of the words will be present in their short-term memory while reading their way through the list. However, in the long-term, that is, for the transfer of decoded units in reading novel words, it would have been more beneficial if they had put more effort into decoding the words, which is required for words presented in random lists.

In addition, the finding that both beginning and dyslexic readers are hampered by the presence of high-frequent neighbours (Chapter 6), also questions the significance of practicing words in a context of highly similar words. It might be that children need to practice highly similar words together in order to fine-tune their orthographic representations. However, in the case of dyslexic and beginning readers it might also be the case that the subsequent presentation of highly similar words interferes with the development of orthographic representations. Note that this might also explain the finding of Poole and Levy (2007) that random word lists seem to be more effective in increasing word-recognition accuracy than structured word lists.

7.3 General conclusion and future directions

The joint results of the studies in the current thesis have pushed our knowledge about what does and does not explain the slow and laborious reading in dyslexic readers a bit further. On the one hand, dyslexic readers do not seem to have specific problems in early visual-parsing processes. In other words, they seem to be equally proficient as their normal reading peers in processing graphemes as functional units and just like normal readers they do not seem to use consonantal onset clusters and rimes as perceptual units in reading. Based on the latter result and the results of the cluster training study it was concluded that stimulating the use of sublexical clusters has no additional value in increasing reading speed in dyslexic readers. In order to improve reading fluency, a more promising unit to focus on seems to be the syllable or morpheme. Dutch, Italian, French and Finnish studies (Ecalle, Magnan, & Calmus, 2009; Huemer, Aro, Landerl, & Lyytinen, in press; Tressoldi, Vio, & Iozzino, 2007; Wentink, Van Bon, & Schreuder, 1997) showed that training the use of syllables in word recognition increased reading
speed in both poor and dyslexic readers. However, future studies featuring no-
training control and alternative-training control conditions are needed to replicate
and validate these findings.

On the other hand, dyslexic children do seem to experience specific prob-
lems in mapping parsed graphemes onto their corresponding phonemes. This
finding can partly account for their slower word-recognition speed. In addition,
the finding that dyslexic readers are hampered by the presence of a high-frequent
neighbour and the observation that their word-recognition performance for the
simplest three-letter words is more variable than in normal younger readers both
suggest that their orthographic representations are less stable, less strongly speci-
fied and probably less distinct from similar candidates in the mental lexicon than
in a normal functioning orthographic lexicon. However, more research is needed
to further clarify the causal mechanisms behind the slow reading speed and higher
within-subject variability of dyslexic readers.