The role of orthographic and phonological processing in dyslexia and reading

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Summary

To shift attention from learning to read to reading comprehension, a reader has to become a fluent reader. This means that the reading process is accurate and automatic (e.g., Kuhn & Stahl, 2003). To develop into a fluent reader, reading experience is needed. Every time a word is successfully decoded, word-specific information is obtained. This forms the basis of the self-teaching mechanism (Share, 1995). The self-teaching mechanism enables orthographic learning, in which the orthographic lexicon is amplified. In achieving reading fluency, the orthographic structure of words is helpful. Familiar parts of the words i.e., larger orthographic units, can be used to identify (pseudo)words.

To predict the development of reading fluency several key predictors are identified. Phoneme awareness, knowing that a spoken word exists of a sequence of sounds and the ability to manipulate this, and rapid serial naming, the fast access and retrieval of well-known symbols from memory, are found to be universal predictors (Wagner & Torgesen 1987). Besides these two important predictors, orthographic processing is, more recently, seen as another important predictor of reading fluency (e.g., Cunningham, Perry, & Stanovich, 2001). However, the role of orthographic processing is still under debate; what does orthographic processing mean and is it independent from phonological processes, especially decoding (Burt 2006)?

Unfortunately, not all readers develop into fluent readers. Among the population of dyslexics there is a large heterogeneity in cognitive profiles (Pennington, 2006). The core deficit in dyslexia lies in a phonological processing deficit (Vellutino, Fletcher, Snowling, & Scanlon, 2004). Although there is consensus about this phonological processing deficit, there is less consensus with respect to all reading-related subskills. A common way to address the issue of heterogeneity is to look for subtypes (e.g., Bosse, Tainturier, & Valdois, 2007; Castles & Coltheart, 1993; Wolf & Bowers, 1999). However, these subtype distinctions have been critized (Share, 2008a; Vellutino et al., 2004). Most subtypes are seen as

deterministic single "opposite" causes and overlook the multiplicity and complex patterns in the cognitive profiles (Pennington, 2006).

The aim of the present thesis is to shed light on the importance of orthographic processing. First, in examining orthographic processing as an important predictor of reading, besides phonological processing skills. Second, in investigating orthographic processing as an important source of heterogeneity in cognitive functioning in dyslexics, especially as a source of variable differences within the group of dyslexics.

In Chapter 2, the role of orthographic processing as an important predictor of (polysyllabic) word reading fluency, pseudoword reading fluency and spelling ability was investigated. This was investigated in addition to phoneme awareness, rapid serial naming, and vocabulary as possible predictors. A sample of 129 Dutch children was followed from Grade 2 to Grade 4.The results showed that in predicting both word and pseudoword reading fluency orthographic processing was important, besides phoneme awareness, and in addition there was an increasing role of rapid serial naming. The contribution of vocabulary was only evident in word reading fluency, but not in pseudoword reading fluency. In predicting spelling ability orthographic processing, in particular word-specific orthographic knowledge, was important, next to the increasing role of phoneme awareness. Vocabulary and rapid serial naming were not crucial predictors. In developing into a fluent reader and proficient speller all reading-related processes, as orthographic processing, phoneme awareness, rapid serial naming, and vocabulary, are needed to increase precise and redundant orthographic and phonemic connections, important for fluency (see Perfetti, 1992).

In Chapter 3, first, the predictive role of orthographic processing in word reading fluency was investigated in a sample of 37 dyslexic and 35 control Dutch secondary school students (Grade 10). Second, orthographic processing as an explanation for the heterogeneity in cognitive profiles of dyslexics was investigated, therefore, the phonological-core variable-orthographic differences (PCVOD) model (van der Leij & Morfidi, 2006) was examined. The first assumption of the model that orthographic and

phonological processing were independent contributors to predict word reading fluency, was confirmed. The second assumption of the model was that all dyslexics suffer from a phonological core deficit. The third assumption involved that within the group of dyslexics there existed larger variability in orthographic processing than in phonological processing. In order to investigate the second and third assumption of the PCVOD model, the dyslexics were divided into two subgroups with high ($ORTH^+$) and low ($ORTH^-$) orthographic processing skills. There were no differences between both dyslexic subgroups on phonological processing skills, verbal ability, and on reading experience. Both subgroups had lower levels of phonological processing and reading and spelling skills than the control readers. However, the $ORTH^+$ subgroup outperformed the $ORTH^-$ subgroup on tasks that requires speeded processing, which is essential when words are briefly presented ("flashed"). In sum, the $ORTH^+$ subgroup is better in identifying larger orthographic units.

In Chapter 4, first, the phonological core deficit was investigated among Dutch dyslexic adults. It was confirmed that 56 dyslexic adults performed worse on tasks tapping phonological processing (phonological awareness, rapid serial naming, and also phonological recoding) than 57 control adults and even 23 reading-age control students from Grade 8/9. Second, similar to the young adolescents in Chapter 3, the PCVOD model was examined as an explanation for the heterogeneity of dyslexics. Orthographic processing explained additional variance in word reading fluency after phonological processing was partialed out. Also it was confirmed that among dyslexics the variability in orthographic processing was significantly greater than in phonological processing compared to the control adults. To further investigate the orthographic variability, the dyslexic adults were subdivided on orthographic processing. The best performing dyslexics formed the $ORTH^+$ subgroup, the lowest performing dyslexics formed the $ORTH^-$ subgroup. The $ORTH^+$ subgroup outperformed the $ORTH^-$ subgroup on almost all reading and reading-related tasks. Also, the $ORTH^+$ subgroup had near-normal levels of orthographic processing. Furthermore, alternative explanations for the PCVOD model were excluded.

The better performance of ORTH$^+$ was not due to differences in reading experience, general cognitive ability, or educational attainment.

In Chapter 5, the focus changed from dyslexic readers to the broader defined category of poor readers (lowest 25%). The cognitive profiles of poor readers were compared to typical readers across four different age-groups: in mid-primary school – Grade 4, first class of secondary school – Grade 7, end of secondary school – Grade 10, and adulthood. The same selection test – Dutch word reading fluency –, and same selection criteria were used. The comparison of cognitive profiles was based on the same measures of reading-related processes of phoneme awareness, rapid serial naming, and speeded parallel symbol processing. At all tasks, both reading and reading-related processes, the differences between typical and poor readers were large, confirming a deficit in all three reading-related processes. With respect to reading fluency, the typical readers performed better with age on all reading fluency tasks (Dutch word and pseudoword, and English word reading fluency), whereas the poor readers only performed better when Grade 7 was compared to Grade 4. This indicates a widening gap between the typical and poor readers on reading fluency. The same holds for rapid serial naming. These findings, therefore, support persistent speed limitations in poor readers (e.g., van der Leij & van Daal, 1999), resulting in an average end stage for poor readers that is comparable to the mastery level obtained by the typical readers in Grade 4. In speeded parallel symbol processing and phoneme awareness, a same pattern of early leveling off was seen, however, this was more similar to the typical readers, indicating more stable differences.

This chapter also investigated the heterogeneity of cognitive profiles by using the multiple case study approach. The findings showed there was a large individual variety of persistent problems (confirming Pennington, 2006) in all reading-related processes at all age-groups. The majority of poor readers at all age-groups showed combined weaknesses in reading-related processes, whereas the group with no additional weaknesses was very small or did not exist (as was the case in adulthood). Furthermore, the findings also suggest changes in the cognitive profiles across age.

Weaknesses in rapid serial naming and speeded parallel symbol processing occurred more often at the higher age-groups.

The last chapter (Chapter 6) discussed the main findings from the present thesis in light of three themes: first, the role of orthographic processing in addition to phonological processing as a predictor of reading fluency; second, universality and stability of phonological deficits across age; and third, heterogeneity among dyslexics. In this chapter, in particular, the concept of orthographic processing was investigated and discussed, and related to other reading-related processes. Two kinds of orthographic processing are suggested: "crystallized" orthographic processing (after Share, 2008b) for tasks addressing word-specific orthographic knowledge, that do not include the sublexical level (e.g., *rane* - *rain* paradigm of Olson, Forsberg, Wise, & Rack, 1994), and "fluid" orthographic processing for tasks that appeal to both lexical and sublexical level (e.g., in tasks using brief exposure for identification of larger orthographic units). Finally, the results of the thesis are discussed regarding diagnosing and remediating reading problems, practice, and future research.