Early identification and intervention in children at risk for reading difficulties
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Citation for published version (APA):

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En zo, op die warme, wolkeloze dag, aan de oever van de rivier, kreeg de zwaan les van de vlinder. Hij leerde van de hak op de tak te springen, rommelig te zijn, nooit iets zeker te willen weten, maar ook nooit iets over te slaan.

'İets is niets,' zei de vlinder. 'Dát wel. Maar alles is wel alles.'

'En niets?' vroeg de zwaan.

'Dat zei ik net,' zei de vlinder. 'Dat is iets.'

Uit: Toon Tellegen (2002), 'Misschien wisten zij alles' (pp. 224-225)
Chapter 1

General Introduction

Because one cannot escape reading… The way to interpret the meaning of this statement wholly depends on the ‘one’ it refers to: the person who has become a skilled reader or the one for whom reading is an everyday hindrance. For the skilled reader, reading is so fluent, involuntarily and effortless, that we can call it automatized (Logan, 1997). Having fluent reading skills thus means that a person cannot escape reading because he has to read the string of letters he perceives whether or not he intends to. Given that the string forms a word that is stored in his orthographic lexicon, decoding the letters into this specific word is such a ‘natural’ event, that it happens almost instantaneously. That is not to say that fluent decoding is always faultless. For example, the way a heteronym like ‘present’ ‘row’ or ‘object’ has to be pronounced is highly dependable on its meaning (e.g. ‘So they made a row.’ and, ‘Is this object for real?’). Although a typical reader has the ability to make accurate and fast inferences about the meaning of words depending on its contexts (Rayner & Pollatsek, 1989), even a skilled reader can make reading errors now and then.

How different is the implication of the above statement ‘because one cannot escape reading’ for someone having difficulty with the process of reading, when pronunciation errors are more common than exceptional, particularly on low frequency words (Paizi, Zoccoloti, & Burani, 2011). For such a person, reading is anything but fluent and effortless, and certainly not automatized. A dysfluent reader has to face daily battles with all kinds of mandatory reading material.

Acknowledgement of the existence of reading disability and its effects on academic and professional development has a long history. More than half a century after the first international publication by Morgan (1886), the existence of ‘congenital word blindness’ was to be considered a well-known fact for child clinicians (Grewel, Schenk, & Bladergroen, 1952). It took several decades longer for most primary and secondary schoolteachers to recognize that students who seemingly did not learn to read and spell properly in most cases were not to be characterized as dumb or lazy. Also

1 For ‘letters’ read also other characters symbolizing the sounds of a particular language.
remarkable, since 1886 an abundance of research has been carried out in the area of developmental dyslexia. The number of publications over a period of nearly 25 years (1985-2009) was counted as 3,789, with an average increase of 128 additional publications per 5-year period (Bishop, 2010). Yet, this has not resulted in consensus among scientists about the cognitive basis of the learning disorder.

1.1 State of the art for research on developmental dyslexia

The next section gives a brief sketch of the latest assumptions and leading theories on developmental dyslexia (for a more comprehensive overview, see e.g., Peterson and Pennington, 2012). It is now generally assumed that developmental dyslexia has a genetic component (Giraud & Ramus, 2012; Graham & Fisher, 2013). In accordance with the first notion by Thomas (1905) that some families are more affected than others, we might say that it is a learning disorder that ‘does tend to run in the family’. On average the estimated risk of becoming dyslexic is about ten times greater for a child with a familial history of dyslexia (van der Leij et al., 2013). Also, the neurophysiological evidence that dyslexic brains differ from those of normal readers, both functional and structural is still growing, see, e.g., Richlan, Kronbichler, and Wimmer (2011, 2013). These meta-analyses report converging evidence for reduced neural activation in dyslexic children and adults in response to reading and reading-related tasks in left hemisphere occipitotemporal, temporoparietal and inferior frontal regions, for reduced grey matter volume in left and right temporal regions, as well as structure-function convergence of grey, and to a lesser extent, white matter abnormalities and underactivation in the left hemisphere (see also Vandermosten et al., 2012).

Following the shift in emphasis from visual to language-based accounts in the search for the primary cause of reading disability (Mann, 1991), Tallal (1980) first formulated a temporal processing theory in which difficulty to discriminate between both rapid speech and non-speech sounds accounted for the observed phonological processing deficits in dyslexia. Several years later, Stanovich (1988) introduced his ‘phonological-core variable-difference’

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2 Four times lower than for ADHD, but three times as many as on SLI, although these neuro-developmental disorders are comparable in prevalence and severity, and 17 times as many as on dyscalculia.

3 Note that three of the four included studies were carried out several years before the introduction to this dissertation was written.
model to distinguish between the ‘true’ dyslexic reader and the ‘garden-variety’ poor reader. Since then, it is well established that a phonological deficit is at the core of the disorder and sufficient to cause the literacy problems (e.g., Ramus et al., 2003; Ramus, 2004), although even among adherents of this theoretical view of dyslexia, the exact nature of the difficulties in phonological processing is still subject to much discussion. The various hypotheses that have been proposed concern on one hand the existence of an underlying primary auditory processing deficit (Tallal, 1980; Goswami, Wang, Cruz, Fosker, Mead, & Huss, 2011), and on the other hand the atypical (‘degraded’, ‘implicit’) structure of phonological representations (Boada & Pennington, 2006; Elbro, 1998) or the limited access to otherwise intact representations given specific conditions that require additional cognitive skills (Ramus & Szenkovits, 2008; Ramus, Marshall, Rosen, & van der Lely, 2013). The double-deficit hypothesis provides an extended explanation with the position that the processes underlying naming speed form a second core deficit (Bowers and Wolf, 1993; Wolf and Bowers, 1999).

Still, given the phenotypic heterogeneity of the dyslexic population (Demonet, Taylor & Chaix, 2004), a considerable body of research has questioned the unitary model in which underlying linguistic deficits are the only probable cause of reading disability, supported by evidence that sensory deficits might also be associated. The notion that dyslexics can be characterized by phonological as well as visual sensory impairments is also at the base of the magnocellular ‘to see but not to read’ account of developmental dyslexia (Stein & Walsh, 1997). This theory states that mild impairments of the magnocellular component of the visual system, which is specialized for processing fast temporal information, can explain why dyslexics may have difficulty processing fast incoming sensory information adequately, not only in the domain of reading but in any domain. According to Vidyasagar (2013), the magnocellular dysfunction that can cause dyslexic problems is restricted to a small region near the fovea implicated in covert identification of letters.

Two other aspects of visual processing, associated with the magnocellular system, are visual attention and visuo-spatial attention (Schulte-Körne & Bruder, 2010). Deficient visual attentional processing would be also implicated in the poor performance of speed and visual information processing in dyslexic readers (Ans, Carbonnel, & Valdois, 1998; Valdois, Bosse, Ans, Carbonnel, Zorman, & David, 2003). Based on
the variability in dyslexic reading profile and the evidence that phonological and visuo-attentional deficit are independent sources of reading problems, it has been argued that abnormal visual-attentional difficulties might constitute the second core deficit in dyslexia (Valdois, Bosse, & Tainturier, 2004), or even the core deficit (Vidyasagar & Pammer, 2010).

In learning to read and spell, (sub)skills tend to become automatized with practice. Prominent difficulties in acquiring fluent literacy skills have led to the hypothesis that dyslexics may have an automatization deficit in addition to a phonological deficit (Nicolson & Fawcett, 1990). Dyslexic people have also shown weaker automatized performance in learning situations outside the domain of literacy provided that the learning conditions resemble the learning demands in reading and spelling. In addition to subtle impairments often displayed by children with dyslexia, and which are unrelated to verbal intelligence, questions have been raised about the specificity of dyslexia (e.g., Frith, 1997). The problem with skill automatization suggests that the deficiency in the learning mechanism in reading might be more general in nature. That task performance on computer game learning in dyslexic children was from the onset onwards less efficient in terms of accuracy and speed as compared to normal controls (Nicolson & Fawcett, 2000), match the rate of learning on reading tasks as indicated by learning curves of dyslexic children partaking in repeated reading practice (van der Leij & van Daal, 1989). Even with much practice they seem unable to catch up. With increasing task demands, i.e., choice reaction, the quality of dyslexic learning becomes even poorer, both on word processing tasks (Yap & van der Leij, 1993; van der Leij & van Daal, 1999) and on tasks not involving phonological processing (Nicolson & Fawcett, 2000).

In sum, in the last decades various theories have been proposed to deal with the diverging and converging findings related to the cognitive and neurological aspects in developmental dyslexia. Although all theories do acknowledge the significance of a phonological deficit to explain the behavioural phenomena of the disorder, each have placed its specific emphasis on concurrent dysfunctions in dyslexics. Assumably, in anticipation of the formation of a comprehensive unified account of developmental dyslexia, essential research topics still have to be resolved and bridges to be crossed.
1.2 Process of learning to read in an alphabetic writing system: From learning the code to direct word recognition

Whether or not the international scientific community agrees on the underlying causes of difficulty in acquiring fluent literacy skills, we expect all children with normal intellectual abilities to learn to read and spell within a designated period of time. Failing to do so may not only impact self-esteem and beliefs about abilities and aptitudes (Alexander-Passe, 2008), but may also contribute to the reading impairment (Zequers et al., 2011) and adversely hamper further academic development (Chapman, 1988). For the acquisition of adequate decoding skills opens the route to the next building block of literacy development, reading comprehension. The fluent ‘translation’ of print into sounds, whole words and sentences is conditional in order to have enough attentional resources to effortlessly process the content of a given text, to make it possible to relate the concepts and thoughts that are being conveyed to what has already been learned.

What learning to read in an alphabetic writing system is all about and which stages a pre-reader has to pass to be called a skilled reader is expertly described by Adams (1990) and Ehri (1987). Although pre-readers may recognize words before they have learned the alphabetic principle (Scott & Ehri, 1990), it has little to do with ‘real’ reading. Rather they memorize the correct connection between a familiar logo or other visual cues and the word that goes with it. With the cue removed, most pre-readers fail to display this kind of ‘sight’ word reading. In investigating possible precursors of later reading difficulties in pre-readers, we found that the ability to recognize familiar logos did not differ between children with good and poor pre-literacy skills (unpublished finding). In developing reading ability, beginning readers all have to start from scratch, that is, they have to learn to decipher the ‘code’, the alphabet in Western countries. Only once a child learning to read has mastered the letter-sound correspondences present in his own orthography, and understands how to synthesize single letters into a word, then this ‘route’ of phonological recoding supposedly acts as a self-teaching mechanism (Share, 1995). In time, for frequent and regular words the much faster route of direct word recognition becomes available to the developing reader as well. It may be clear that the ‘sight word reading’ that characterizes the skilled reader is based on quite other abilities than the ‘reading by sight’ of precocious pre-readers.
1.3 Identification of at-risk children

1.3.1 Behavioural precursors

Not that many years ago, it was generally assumed that all pre-readers resembled a blank slate insofar reading and spelling was concerned. Before the start of formal schooling, children visited kindergarten\(^4\) for at least one year to facilitate the transition from the home environment to the school system, while having the opportunity to acquire new social and cognitive skills by play-based interactions with peers and new adults. The acquisition of the basis academic skills, reading, spelling, writing and mathematical computation was considered to start in Grade 1\(^5\). Whether or not children would experience difficulties with the process of learning to read was to be awaited until one or two years later. The common view of first grade teachers was that given differences in cognitive readiness for formal learning, some children might lag behind for a while only to catch up later. Once it became clear - after about two years of reading instruction - that the gap in reading achievement was getting too big the most serious cases were offered extra support. However, in the case of severe dyslexia, remediation in older children has not proven to be very successful (e.g., van Daal & Reitsma, 1999). The thought was raised whether it would not be more efficient and less disadvantageous if pre-readers at risk for reading disabilities were offered intervention before the onset of reading education. Results from intervention research described by Torgesen (2001, 2006) show indeed that sustained preventive intervention proved to be more effective than remediation of reading deficits at a later stage of development, in particular for the outcome of fluency.

So, instead of holding on to a ‘wait and see’ policy, schools may do better to consider which of the pre- or beginning readers could be labelled as being at risk. Providing the use of a sound method, the majority of first graders will respond well to the regular reading program at school, acquiring the necessary literacy skills at an appropriate pace. The challenge is to identify the children in need of extra attention, for whom early interventional support is essential in order to prevent the development of (severe) reading and spelling problems. Opting to select potential poor or dyslexic readers when still in the pre-reading phase of their literacy development and to have the proportion of false-positives or false-negatives

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\(^4\) In the Netherlands from the age of four or five years onwards

\(^5\) Children start Grade 1 in September in the calendar year they become six.
minimized obviously requires a suitable screening instrument. It is important to note that an alternative for diagnosis based on behavioural tests, Response-to-Instruction (RTI; Fuchs & Fuchs, 2006) as a means of early identification, is not feasible because there is no formal literacy instruction in the pre-reading phase.

One of the most important precursors of later reading skills already mentioned above has found to be knowledge of the grapheme to phoneme relations. Knowing how to link the letters of the alphabet – the single ones but also two or more letter combinations (digraphs, etc.) to their (distinctive) sounds is a prerequisite for the next step: learning how to blend these sounds into a word. Having little letter knowledge before the start of formal reading instruction may just be a case of experience, e.g., less exposure to informal, home-based literacy activities. As soon as a child with less involvement with such activities begins formal schooling, it likely will catch up with his more advanced peers before the first semester has come to an end. On the other hand, low letter knowledge or a lack of interest to acquire some letter knowledge in a pre-reader may well signal a predisposition for problems with the acquisition of more advanced reading skills (e.g. Boets et al., 2010; de Jong & van der Leij, 1999; Pennington & Lefly, 2001; Scarborough, 1998; 2009; Snowling, Gallagher, & Frith, 2003; Torppa, Poikkeus, Laakso, Eklund, & Lyytinen, 2006). Thus, the number of letters a particular pre-reader is able to name or to sound out may be an indication whether or not this child is at risk and in need of preventive intervention. Screening is however more informative when other relevant precursors are also incorporated.

To make a more conclusive judgement about the risk status of a pre-reader, it seems sensible to consider early phonological abilities as well. Given that it is generally assumed that a phonological deficit is at the core of the disorder (Ramus et al., 2003), not surprisingly, dyslexics often perform more poorly than fluent readers on tasks that require awareness and manipulating of the phonological structure of words. In addition, many dyslexics have relatively more difficulty with the rapid retrieval of the names of familiar (alphanumeric) symbols from memory and also poor verbal short-term memory (de Jong & van der Leij, 2003; Ramus, Marshall, Rosen, & van der Lely, 2013).

When being exposed to language, young children gradually develop phonological sensitivity or awareness, in the sense that they are able to ‘break’ chunks of language into ever smaller units, like sentences into words.
and words into syllables, or into bodies (the part /ca/ in ‘cat’, or rimes (the part /at/ in ‘cat’). Most five-years-olds consider playing games with rime as fun. But being able to tell whether ‘cat’ rimes on ‘sat’ is of a different (lower) level of phonological sensitivity than being aware that words are composed of discrete sounds (phonemes) (Lonigan, Burgess, Anthony, & Barker, 1998). Although the more advanced children may already display some awareness for phonemes before they start learning to read, in the majority of children the ability to segment a spoken word like ‘cat’ into the phonemes /c/, /a/, and /t/, and blend them again to form the whole word develops in concert with learning to read.

Due to its reciprocal relationship with reading acquisition (Perfetti, 1992), progress in phonological ability is rather fast in most beginning readers in a relatively consistent orthography like Dutch. The results of de Jong & van der Leij (1999) on two categorization tests show that whereas performances could be reliably tested within a few months of reading instruction, in kindergarten performance was still at or slightly above chance levels. Not unexpectedly so, because in the nineties of the previous century not many Dutch kindergartners had the opportunity to acquire higher levelled phonological abilities at school. Consequently, only after the start of phonics based reading instruction in Grade 1, it became clear which of the children did not readily develop phoneme awareness and were at risk for problems with reading acquisition. Even though in the last decennium the Dutch policy has changed with respect to the implementation of pre-literacy school activities, the kindergarten curriculum does not include activities other than exercises to promote and enhance metalinguistic and letter-sound knowledge. Given the rapid growth in phonological ability once reading instruction has begun in Grade 1, the potency of phonological awareness as an early predictor of learning problems remains therefore time-limited, as argued by de Jong & van der Leij (1999).

In a meta-analysis of the effects of phonological awareness training on reading acquisition, Bus and van IJzendoorn (1999) reached a similar conclusion. Training in phonological awareness appears to facilitate the process of learning to read, but not necessarily affects later outcomes. When training incorporates letter-sound correspondences however, the effects on reading skill become stronger. So, along side with letter knowledge, phonological awareness ability can be seen as an important condition during the initial stages in the process of learning to read. Accordingly, as a early predictor its usefulness is foremost conditional on the level of phonological
awareness - not to low, not to high - in a particular sample (de Jong & van der Leij, 1999). In Dutch children such an intermediate level is usually found after several months of reading instruction.

The other phonological processing skills relevant to reading acquisition and quite reliable assessable from kindergarten age onwards are phonological or verbal short-term memory and the speed with which phonological codes can be retrieved from memory. Phonological memory has been found to contribute to vocabulary acquisition (Baddeley, Gathercole, & Papagno, 1998), but also to the acquisition of letter knowledge (de Jong & Olson, 2004). The latter effect confirmed the assumption of the authors that learning letter names and sounds is similar to learning novel words and is suggestive of a relation between the individual differences in the growth of letter knowledge and individual differences in phonological memory. Although phonological memory has also been found to correlate significantly with reading acquisition, this phonological ability does not make a unique contribution to reading skills, but seems to share its predictive variance with phonological awareness (e.g., de Jong & van der Leij, 1999; Parrila, Kirby, & McQuarrie, 2004).

Compared to the more time-limited predictive relationship of phonological awareness with reading outcome (de Jong & van der Leij, 1999), rapid automatized naming has proven to be an independent and stable predictor of individual differences in reading proficiency (Torgesen, Wagner, Rashotte, Burgess, & Hecht (1997). Both children and adults with reading deficits are slower in the speeded access to various series of symbols than children and adults without (Wolf, 1991). Because naming speed tasks were found to contribute to the variance in reading acquisition independent of phonological measures, the processes underlying naming speed have been identified as a second source of reading disability (Wolf et al., 2002). However, a disadvantage to identifying at risk children before the onset of learning to read is that naming speed for non-symbol items, like colours and objects shows a weaker association with reading than the naming speed for later developed alphanumeric items (digits, letters) (Bowey, McGuigan, & Ruschené, 2005). Also, slow naming may not only be related with reading deficiency, but might reflect a more systemic problem, that is, a global problem with processing speed (Kail, Hall, & Caskey (1999). Recently, while examining the relation between phonological skills and reading speed as a function of word length, it was found that individual differences in the length effect (a marker of the reading process) could be predicted by
phonological awareness, whereas rapid naming could only account for differences in overall reading speed (van den Boer, de Jong, & Haentjens-van Meeteren, 2013). It may explain why naming speed unlike phonological awareness is less susceptible to intervention or improvement (de Jong & Vrielink, 2004; Eleveld, 2005).

1.3.2 Neurobiological precursors

There is wide agreement that dyslexia is neurobiological in origin (Lyon, Shaywitz, & Shaywitz (2003), and that the neural correlates are quite consistent across different orthographies (Peterson & Pennington, 2012). The range of approaches and methodologies (electroencephalography (EEG), functional and structural neuroimaging techniques) to evaluate the functioning of the brain and the underlying phonological and orthographic processes during reading is still expanding. These recent investigations provide increasing insight into the neural bases of typical and atypical characteristics of the (developing) reading brain. But despite the abundant work about reading-related brain activation in fluent and less fluent readers, supplemented with research on the effects of intervention on neural processes in reading impaired children (for a review, see e.g., Caylak, 2009), much less is known about reading-related brain activation in children with no or little reading experience (but see the interesting series of studies by Maurer and colleagues: Maurer, Brem, Bucher, & Brandeis, 2005; Maurer et al., 2006; Maurer et al., 2007). By recording event-related potentials (ERPs) to word decoding, Chapter 4 aims to investigate the facilitating influence of picture primes on phonological processing in children at risk of familial dyslexia (FR) following a short early intervention in kindergarten.

Literature about early neural markers of latent reading failure based on tasks that make no demands on phonological and orthographic processing abilities appears to be even scarcer. This seems rather to be expected since dyslexia is widely considered a specific learning disorder - with phonology as the core problem (Vellutino, Fletcher, Snowling, & Scanlon, 2004). However, Lyytinen (1997) has pointed out that the developmental course leading to deficient acquisition of phonological skills is not well known. Therefore, all kinds of perceptual and learning difficulties - that in older children may have been compensated for and go unnoticed – may affect in young children the automatization of all kinds of skills like for instance visual-motor integration skills or letter-sound integration.
In two extensive prospective projects, one Finnish (Jyväskyla Longitudinal Study, JLD), one Dutch (Dutch Dyslexia Programme, DDP), children at family risk were followed from birth. The large number of studied variables included various measures of learning outside the literacy domain, i.e., auditory and speech processing (see for an overview, van der Leij et al., 2013). Studies investigating auditory ERPs found evidence that proficient low-level auditory processing might be regarded as one of the precursors of word reading fluency (Leppänen et al., 2010; Plakas, van Zuijen, van Leeuwen, Thomson, & van der Leij, 2013; van Zuijen et al., 2012), although the predictive value of atypical auditory processing in pre-readers for subsequent literacy failure remains inconclusive.

Significant differences in brain functioning between Finnish and Dutch samples of FR newborns and controls were also found for automatic speech perception (e.g., Leppänen, Pihko, Eklund, & Lyytinen, 1999), synthetic speech sounds like /ba/, /da/, /ga/ (e.g., Guttorm, Leppänen, Richardson, & Lyytinen, 2001), or /bAk/ (Been et al., 2008); and /bAk/ /dAk/ paradigms (van Herten et al., 2008; van Leeuwen et al., 2006, 2007, 2008). Newborn ERPs from the sample of the Guttorm et al. study, were predictive of receptive language skills at 2.5 and 5 years of age (Guttorm et al., 2005), and at the age of 6.5 years, only at-risk infants with atypical speech processing performed significantly lower than controls in pre-literacy measures including letter knowledge, phonological skills and rapid naming (Guttorm, Leppänen, Hämäläinen, Eklund, & Lyytinen (2010). In two Dutch samples, relationships were found between later reading fluency in Grade 2 and early ERPs to speech sounds at 2 months (van Zuijen, Plakas, Maassen, Maurits, & van der Leij, 2013) and at 17 and 29 months (Maassen, van der Leij, Maurits, & Zwarts, 2012). These findings indicate that early atypical speech processing might be a predictor of reading difficulties, as already suggested by the work of Molfese and colleagues (Espy, Molfese, Molfese, & Modgline, 2004; Molfese, 2000; Molfese, Molfese, & Modgline, 2001). Interestingly, because in older children, impaired speech perception is particular associated with language impairment, and apparent only in a subset of dyslexics (Joanisse, Manis, Keating, & Seidenberg, 2000).

Impaired speech perception in at risk children who develop reading problems are not quite unexpected, given that these deficits originate from phonological rather than general and auditory deficits (Mody, Studdert-Kennedy, & Brady, 1997). Although there is still controversy regarding visual processing deficits underlying developmental dyslexia, at least one
study parallel to the DDP has found evidence that visual information processing might also be implicated in FR children. In an ERP study using visuo-spatial orienting, Dutch infants at the age of 5 months showed diminished cortical responses to spatial cues as compared to controls. Similar results were found in dyslexic adults (Dhar, 2009). Converging behavioural findings support the view that visual impairments are not necessarily the consequence of reading failure, but may already exist before the start of reading acquisition and predictive of early literacy skills (Facoetti, Corradi, Ruffino, Gori, & Zorzi, 2010; Franceschini, Gori, Ruffino, Pedrolli, & Facoetti, 2012; Kevan & Pammer, 2008, 2009). As part of the intervention component of the DDP, the ERP study in Chapter 2 examines the relation between pre-attentive visual processing and attentive learning as implicated in reading and spelling using a habituation paradigm in FR pre-readers.

1.4 Early intervention in at-risk children

Early identification of children at risk of reading difficulties before the onset of learning to read is also crucial for the design of early interventions. With respect to early interventions for pre-readers at risk, these are typically designed to provide them with a head start in literacy progress. Thus the emphasis is on enhancing and strengthening skills in the domain of reading and spelling, analogous to remedial approaches in older children with reading difficulties (but for an account of alternative approaches, see Fawcett & Reid, 2009). This may not come as a surprise given that the most important preliterate skills phonological awareness and letter knowledge qualify as behavioural precursors in dyslexia and are considered to be the building blocks of reading acquisition (see section 1.3.1).

Early interventions may differ considerably on a number of features other than that they are bound to begin in a stage in which children have little or no experience with literacy activities. For instance, the two intervention studies included in his thesis (Chapter 3 and 5 respectively) are comparable in several of programme characteristics mentioned hereafter, while contrasting in others. Important characteristics on which early interventions have been found to differ are sample size, inclusion criteria (FR and/or behavioural risk criterion, or no inclusion criteria), training content (phonological awareness, letter knowledge, naming speed, vocabulary, word decoding) duration (from several weeks to more than one
school year) and intensity (number of sessions per week, number of minutes per session), setting (at school or at home), administration (individually, in small groups or whole classes; computer-assisted or not; (non)professional tutor-assisted or no tutoring). It may be clear that all these set-up characteristics together with choice of (outcome) measures contribute to the outcome effectiveness of a particular intervention. As shown in an overview (van der Leij, 2013), the main results (effect sizes) of six early interventions directed at FR pre-readers, executed in Denmark (1), Australia (1), and the Netherlands (4), vary considerably. Remarkably, despite significant gains in phonemic awareness and letter knowledge in the trained Dutch FR Kindergartners, in none of the four DDP studies, there were transfer effects to reading in Grade 1. Note, however that akin to what is standard in Dutch research the focus was on fluency as an indicator of reading competence. In a Dutch sample of unselected Kindergartners, phoneme awareness at the beginning of Grade 1 appeared to predict reading accuracy but not fluency (Verhagen, Aarnoutse, & van Leeuwen, 2008).

In evaluating and comparing the efficacy of intervention programmes, apart from differences in design it is important to consider invariant context conditions as orthographic and educational system that cannot be controlled by the researcher. As argued previously (van der Leij, 2013; van Otterloo and van der Leij, 2009), such contextual differences may affect comparability across countries and orthographies. Learning to read accurately in a shallow orthography with consistent 1:1 mappings between graphemes and phonemes and a simple syllabic structure is easier than in languages with deep orthographies that contain many orthographic inconsistencies as well as syllabic complexities (see e.g., Seymour, Aro, & Erskine, 2003).

Compared to English and Danish, which are both deep orthographies with many orthographic inconsistencies as well as complexities, Dutch is a relatively consistent orthography, although some letter-sound combinations and syllabic complexities may affect the progress in reading and spelling after the initial steps in reading acquisition have been made. In comparison to interventions in consistent orthographies, you might say there is more to gain while providing additional instruction to at-risk children learning to read in languages with deep orthographies. In addition, when the educational system within a country is well organized and formal reading curriculum is based on phonics-based instruction, as in the Netherlands, there might be less to gain. This is particularly the case with respect to the
first goal in learning to read, attaining decoding accuracy, until recently, traditionally used as the primary outcome measure in English based reading research (Fuchs, Fuchs, Hosp, & Jenkins, 2001). However, after a level of high accuracy has been reached, further skill development requires the speeding-up of accurate decoding. Automaticity - fluent and effortless decoding that enables the reader to focus his attention on comprehension, but found to be impaired in dyslexic children (see van der Leij en van Daal, 1999; Yap & van der Leij, 1993) - is the ultimate goal of reading instruction (Samuels & Flor, 1997). Therefore fluency level should always be taken as the most important outcome in academic and research settings. As it is, even in a consistent orthography, with proper education accessible to all children, a relatively high percentage of students are reported to have reading difficulties (Inspectie van het Onderwijs, 2007) as assessed by timed reading tasks. However, if slow dysfluent readers are engaged in focused practice over an extended period of time, the expectation is that virtual all of them can achieve automaticity (Samuels & Flor, 1997). In line with this view, several adjustments were made to the intervention reported in Chapter 5 following the Chapter 3 study.

1.5 Outline of the thesis

The present thesis is based on four studies. The first three studies were carried out as part of the longitudinal project ‘Early diagnosis and treatment of developmental dyslexia’, being the intervention component of the three components of the Dutch Dyslexia Programme (DDP),6 funded by The Netherlands Organisation for Scientific Research, and initiated and executed by the University of Amsterdam, the University of Groningen, and the Radboud University Nijmegen. The fourth study is part of a longitudinal project within the broader framework of Onderwijs Bewijs I,7 a national programme initiated by the Netherlands Ministry of Education, Science and Culture (OCW) to promote the use of educational approaches shaped by evidence-based practice.

As can be derived from the title of the DDP intervention project, the two main topics that are addressed in this thesis are early identification and intervention in children at risk of developmental dyslexia. The topic early identification is covered by two ERP studies presented in Chapter 2 and 4,

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6 Registration number: NWO262-89-011
7 Project number: ODB08052
each with its own focus and aim. The second topic dealing with early intervention is also covered by two studies, which are presented in Chapter 3 and 5. In both studies children at risk for reading difficulties were provided with early intervention. In line with the initial emphasis of the thesis, the participants in the early intervention study in Chapter 3 were selected on the basis of a familial risk of dyslexia. However, in the course of the thesis the scope of the intervention topic was enlarged to also cover the impact of early intervention in children at high cognitive risk for problems with reading acquisition. The reason is twofold. First, not all reading difficulties can be retraced to a familial history of dyslexia, and second, not all early reading difficulties develop into such severe problems that a diagnosis of dyslexia is warranted.

In the following, the outline of the thesis is presented according to the order of the chapters. **Chapter 2** concerns the results of a study aimed at investigating whether deficits in the learning mechanisms of dyslexic children may be more general than specific, that is to say, related to deficits at a more basic level of information processing, which impede attentive learning and skill automatization. Using a habituation paradigm, the orienting behaviour on a visual task with low attention load was recorded with ERPs in a sample of kindergartners with and without a familial history of dyslexia. Subsequently, while in second grade the acquisition of reading and spelling was assessed in order to relate pre-attentive learning in the pre-reading phase to attentive learning performance as implicated in reading and spelling.

Regarding the second topic, the aim was to develop and revise an early intervention to prevent the development of (severe) reading problems. The study reported in **Chapter 3** investigates the longitudinal effectiveness of the first version of a tutor-assisted program formed after an American remedial intervention. Being computerized, the program is made suitable for delivery by non-professionals. Subjects were again kindergartners, all at familial risk of dyslexia. When still in the pre-reading phase, these children received a combined training in phoneme awareness, letter knowledge and basic decoding, at home, with the parents in the role of tutor. To assess the short- and long-term effects of training, (pre-)literacy performance of the trained subjects was compared to that of the at-risk and not at-risk subjects partaking in the study described in Chapter 2.

The ERP study described in **Chapter 4** linked the topic of early diagnosis with the advances in (pre-)literacy skills following early
INTERVENTION. A subsample of the subjects at familial risk partaking in the Chapter 3 intervention was divided into two subgroups based on emergent literacy skills at the end of kindergarten. The behavioural and neural correlates of picture-primed word identification were studied regarding group-related differences in integration of phonological and orthographic information, as well as in congruent information processing.

Chapter 5 presents data sampled at school in a cohort of first graders selected by their teacher as being at cognitive risk for developing reading difficulties. The aim of this study is to provide evidence that the computerized and tutor-assisted program used in the home-based intervention reported in Chapter 3 suits all beginning at-risk readers in need of additional reading support. To accommodate the successive stages in learning to read up to the stage of automatization, a prolonged and adapted version of the program was used.

The thesis concludes with Chapter 6, consisting of a general discussion regarding the key findings of the included studies and their theoretical and practical implications.