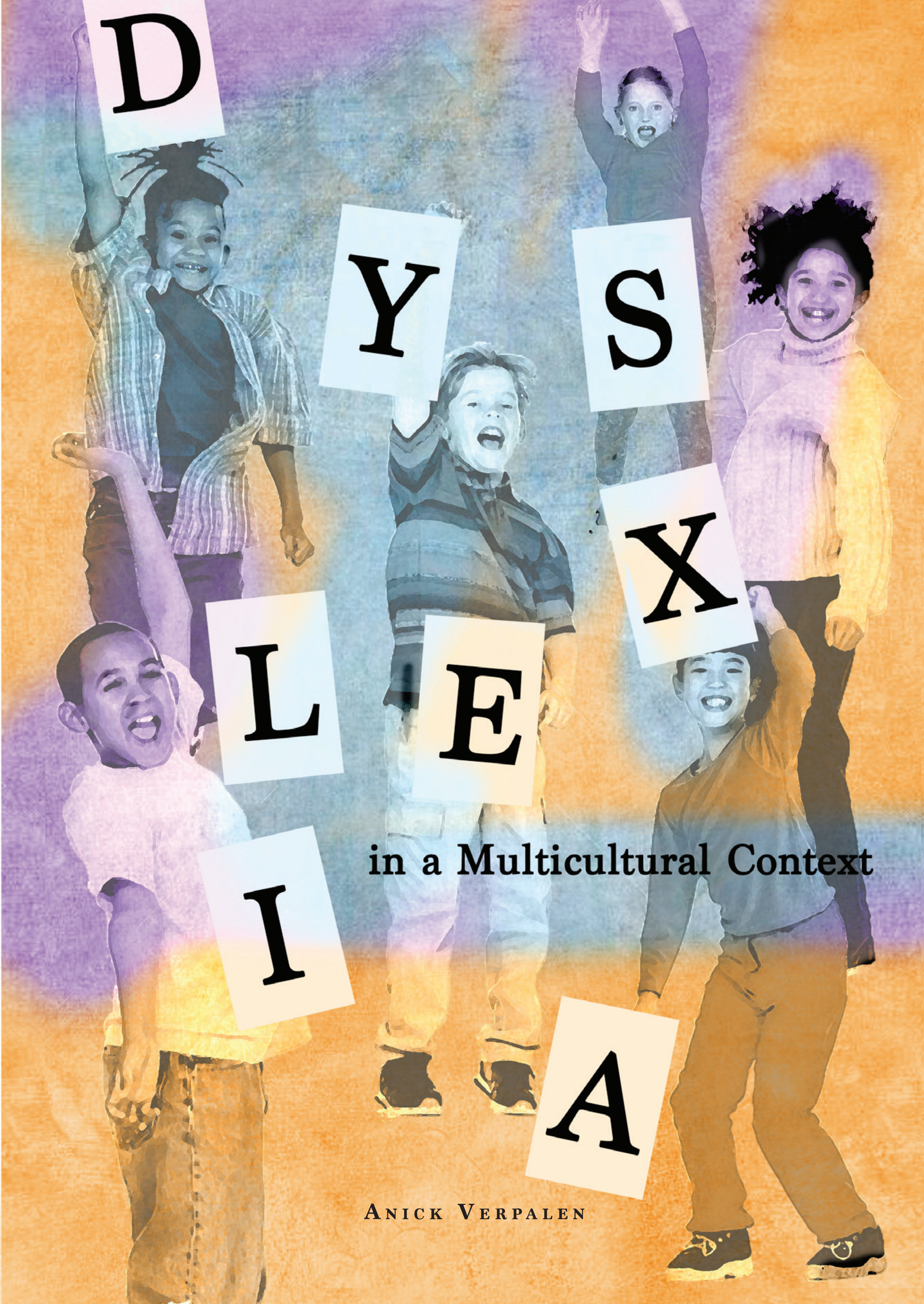
Dyslexia in a Multicultural Context

Verpalen, Anick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in a Multicultural Context
Anick Verpalen

Dyslexia in a Multicultural Context

Voor mijn allerliefste vader Jan Verpalen (1944-2012)

die ik nog elke dag ontzettend mis

Anick Verpalen

Dyslexia in a Multicultural Context

Proefschrift ter verkrijging van de graad van doctor

aan Tilburg University

op gezag van de rector magnificus, prof. dr. E. H. L. Aarts,

in het openbaar te verdedigen ten overstaan van een

door het college voor promoties aangewezen commissie

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Johanna Martina Philomena Verpalen

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	Prof. dr. A. M. Backus
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Chapter 1

An Introduction

Dyslexia

Dyslexia has come to be a well-known name for a learning disorder that shows up as difficulties in reading and spelling development. A long period of research preceded the formal definition of this learning disorder and clarified its causal aspects. Dyslexia was first described from a medical perspective as 'word blindness', the term used by the eye surgeon James Hinshelwood in 1917 (Nicolson & Fawcett, 2010). In 1968, developmental dyslexia was formally defined as: 'a disorder in children who, despite conventional classroom experience, fail to attain the language skills or reading, writing and spelling commensurate with their intelligence' (World Federation of Neurology, 1968). An important aspect of the definition is a significant discrepancy between the reading and spelling performance on the one hand and expectations based on the child's intelligence on the other. Vellutino (1979) argued that dyslexia was not just a deficit in visual processing, but also, and probably mostly, a deficit in language processing and this insight changed the focus of dyslexia research. Literature on the causes of dyslexia was dominated by the phonological deficit hypothesis: phonological weaknesses were seen as the cause of dyslexics' reading difficulties. In the 1990s, Wolf and Bowers (1999) proposed an alternative hypothesis, in line with one of the most characteristic symptoms of dyslexia: lack of fluency in reading and slow performance on rapid naming tasks (e.g., tasks in which a child has to name as quickly as possible the pictures, letters, colours, or digits included on some stimulus material, such as a sheet of paper: such tasks are associated with fluent reading skills). This has become known as the double deficit hypothesis, with phonological deficits and naming speed deficits as two separate sources of reading difficulties. They identified three subtypes of dyslexics: dyslexics with phonological deficits, dyslexics with speed deficits, and dyslexics with both.

New research possibilities arrived with the introduction of fMRI scans and other imaging techniques that allow studying activity in the brain during reading and spelling. Reading and spelling seem to be very complex activities and they involve many areas in the brain. Brain research has suggested a delayed development in reading and spelling, and specific dyslexia-related difficulties. Differences in the activity of various brain areas cause different problems in reading and spelling development (for an overview, see Démonet, Taylor, & Craix, 2004). These findings are in line with the idea that there are different types of dyslexia, in children as well as in adults. Some dyslexics have problems with reading, some with spelling, and most of them with both. Beside these technical problems, some dyslexics have problems with phonological awareness, some with visual skills (e.g., switched letters or numbers), some have problems with the speed of these skills, others with the accurateness of these skills. Most of them have a combination of these difficulties. These skills are also important and universal predictors of reading and spelling performance and not restricted to the first language (Chiappe, Siegel, & Gottardo, 2002; Limbos & Geva, 2001; Geva & Siegel, 2000; Verhoeven, 1994). Since the first official Dutch protocols (Blomert, 2006; SDN, 2000) for assessment and treatment were published, based on the phonological deficit theory, the visual aspects have recently regained attention in the update of this protocol in November 2016. In practice, however, specific tests and instruments to measure the visual aspects of dyslexia are not mentioned in the protocol yet, though an update of the protocol will probably be published soon. Although 21% of the Dutch population has at least one foreign born parent, research about dyslexics is limited in the Netherlands (Statistics Netherlands, 2014) and does not include first- or second-generation immigrants, which underscores the relevance of this dissertation, both from a scientific and practical perspective.

In the Netherlands, primary and secondary schools are familiar with dyslexia screening, when children show reading and spelling difficulties and remedial teaching is not very effective. In a multicultural population, it appears to be more difficult to identify children at risk for dyslexia (Cline, 2000; Peer & Reid, 2000). If Dutch is not the home language of the child, lower scores on language related tests (e.g., tests for technical reading, spelling, and reading comprehension) may often erroneously be attributed to a lack in second language development and vocabulary knowledge. In addition, cultural factors can influence children's test scores if their cultural background differs from the Dutch culture. The present dissertation is based on the two issues described above: the complexity of dyslexia, its indicators, and the specific dyslexia difficulties of Dutch and immigrant dyslexic children, and the possibilities and difficulties involved in the screening and assessment of dyslexia in Dutch and immigrant children in a fair way.

Bias

Children differ in their home environments, with their differences in cultural settings and habits, which are crucial in child development. The context in which children construct and acquire their knowledge should be taken into account when we try to understand children's development, because every one of their cognitive acts can be viewed as a response to this context (Resnick, 1991). Differences in ways of relating to objects or people and different ways of understanding will influence cognition and lead to both different and similar patterns of cognitive organization (Del Rosario Basterra, 2011; Saalbach & Imai, 2007). The influence of culture on cognition makes it a challenge to assess children from diverse cultural backgrounds in an equitable and valid manner.

At the same time, language is a part of learning and assessment. A language system is a cultural symbolic system of sounds and words, the vehicle through which a culture communicates ideas, thoughts, feelings, knowledge, and meanings (Gopaul-McNicol & Armour-Thomas, 2002). Assessment depends on language in its administration, its instruction, and also in the way children interpret the test items and give their responses in school tasks (Trumbull & Solano-Flores, 2011). Immigrant children who speak another language at home usually learn the majority language as a second language, mostly when they start kindergarten or primary school, and are often disadvantaged in their language abilities in the majority language, compared with their mainstream classmates. Immigrant children may have a smaller vocabulary, a general lack of easy understanding things said to them in the majority language, and more tip-of-the tongue lexical retrieval failures (Gollan & Brown, 2006; Hamers & Blanc, 2000). Research often shows lower test scores for immigrant children on diverse linguistic tasks such as verbal fluency tests (Gollan, Montoya, & Werner, 2002) and picture naming tests (Gollan & Brown, 2006).

Several factors (e.g., educational home environment, language, culture, poverty) may contribute to immigrants' underachievement on tests and assessments, including also in school tests of reading and spelling ability. The influence of these confounding cultural factors on the way children interpret test items and respond to them is called bias (Solano-Flores, 2011; Van de Vijver & Leung, 1997).

Cross-cultural psychology distinguishes three types of bias. The term ‘construct bias’ is used when there is an incomplete overlap of constructs across cultural groups, so that the construct does not measure identically across the groups. ‘Method bias’ is the measurement of anomalies related to the administration of an instrument or test features induce score differences between cultural groups. ‘Item bias’ refers to anomalies at item level, such as problems caused by poor item translation (Van de Vijver & Poortinga, 2005). As a consequence of cultural bias, immigrant children could underperform in tests, which especially makes dyslexia screening and assessment more complicated because of its association with language. Each of these biases poses a challenge to the assessment of dyslexia in immigrant children.

Literacy development in a second language

Migration is a main factor in bilingualism in Europe (including the Netherlands) and the United States (CBS, 2016; O’Bryon, 2014; Tabouret-Keller, 2006). There are various reasons for migration, such as finding work, family reunion, and seeking freedom, safety (refugees) or better life conditions (CBS, 2016; Tabouret-Keller, 2006). Most of the immigrant children in the Netherlands are first (born in a non-western country) or second generation (one of the parents or both are born in a non-western country), although a third generation is forming (one or both of the grandparents are born in a non-western country) (CBS, 2016). First generation children start their Dutch education at different ages, depending on when they arrive in the Netherlands. The second and third generations start nursery school mostly at the age of two, and primary school when they are four years old. The home language is often the mother tongue of the parents, because one or both of the parents do not speak Dutch very well. Exposure to the Dutch language starts mostly in nursery school, or in primary school when the parents do not opt for nursery school. Immigrant children learn literacy skills in the second language, which they often do not speak very well during the first years of formal schooling (Bialystok, 2001). Universal reading and spelling components, which do not involve language-particular aspects such as letters and sounds develop when a child learns to read and spell. The general mapping principle, mapping a sound to a symbol, is a universal component of reading. If these skills have been developed in one language they can facilitate literacy development in a second language, and thus could serve as an advantage for children who already learned to read and spell in their first language (Koda, 2008; Verhoeven, 1994). Disadvantages that stem from learning to read in a second language could be, firstly, having to deal with differences between the scripts used in the first and the second language and their degree of transparency (the way a written letter corresponds to a sound in pronunciation) and, secondly, having to work with a smaller vocabulary, which will for example cause less word recognition (Barlett, 2001; Gottardo, Collins, Baciu, & Gebotys, 2008). On the other hand, research has shown a fairly limited role of verbal language proficiency in determining reading ability, which means that after literacy instruction in formal schooling children are able to decode words in a second language as well (Geva, 2000; Durgunoğlu, Nagy, & Hancin-Bhatt, 1993).

Dyslexia and second language learning

Dyslexia is found in all languages in which it has been studied (for a review, see Smythe, Everatt, & Salter, 2004). Differences in phonological complexity and orthographic transparency cause cross-cultural differences in the manifestation of dyslexia (Goswami, 2008). There is a universal agreement that children with dyslexia, have difficulties with phonological skills, (e.g., phonological awareness (e.g., rhyming), rapid automatized naming skills (naming letters, naming pictures), and with sound-letter mapping skills (letter identification), beside general reading and spelling problems (Goswami, 2008). Research has shown that these skills are strongly related to individual differences in word reading skills and can predict reading ability in both the first and second language (Durgunoğlu et al., 1993; Geva, 2000). These cognitive and linguistic difficulties are caused by universal aspects of brain activity: children with dyslexia show under-activation in several brain areas associated with reading and spelling while engaged in the above mentioned reading related tasks (e.g., letter identification, single letter rhyme, non-word rhyming) (Shaywitz et al., 2002). The few brain studies of bilingual dyslexics have found the same patterns (Oren & Breznitz, 2005; You et al., 2010). These findings are in line with the idea that dyslexic bilingual children are struggling with the same difficulties as monolingual children, possibly exacerbated by their delayed second language ability.

This dissertation

This dissertation addresses the complexity of dyslexia, as found in recent work, including my own. First, I study these aspects in a multicultural context. Because of the increasing multicultural nature of the population of the Netherlands, I start with examining performance on an existing dyslexia screening test (DST-NL) by Dutch and immigrant 8- and 9-year old children in the fifth grade of primary school, when they already are able to read in a somewhat fluent way. I compare the test scores of these groups to detect bias and to examine the influence of vocabulary knowledge and the educational level of the parents. I also determine which subtests are more difficult for immigrant children and examine the characteristics of these tests. Second, I examine the role of bias in detecting dyslexia in immigrant children, when they are just starting to learn to read (third graders) and compare the outcomes with those of somewhat fluent readers (fifth grade). Given the prevailing view of the universal neurocognitive basis for dyslexia, developmental dyslexia should develop in the same way, regardless of cultural or linguistic background (Goswami, 2008; Shaywitz et al., 2002). I try to get more insight into the development of reading and spelling skills in Dutch and immigrant children and into the possibility that the growing size of the vocabulary and the influence of schooling may decrease the influence of bias in dyslexia screening. Thirdly, I examine the adequacy of dyslexia screening with the DST-NL, and the outcomes of the Dutch dyslexia protocol, in a longitudinal and cross-sectional study. I study the predictive accuracy of the subtests and the protocol outcome (dyslexic or not), to address bias in both the DST and the protocol. I try to compare dyslexia in Dutch and immigrant children, at the first stage (beginning reader in the third grade), at the middle stage (less fluent reader in the fifth grade) and at a later stage (fluent and experienced reader in the seventh grade), and discuss what tasks are the most effective for detecting dyslexia in these children. I use the outcomes of these three studies in the fourth and last study, in which I construct a new dyslexia screening test with tasks that rely less on vocabulary knowledge and cultural knowledge. I examine the new test in the fifth and seventh grade and analyze the new tests for bias. I compare the predictive accuracy of the test items and the total score for detecting dyslexia in, again, Dutch and immigrant children, and study the validity of the new test.

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Chapter 2

Group Differences in Dyslexia Screening Test Scores Between 8- and 9-year-old Dutch and Immigrant Children

Introduction

Dyslexia is a disorder in reading skills, reading, and spelling development. The prevalence of dyslexia is 4-5% in the Netherlands (Blomert, 2005, 2006). Dyslexia mainly affects children with a normal intelligence and educational skills. Several twin and family studies suggest a genetic influence and showed a higher rate of dyslexia within some families (Pennington & Olson, 2005; Theng, 2002). Having dyslexia can adversely affect learning possibilities, which makes it important to detect dyslexia as early as possible in the school career. With dedicated help and treatment, children can function in line with their real opportunities and intelligence.

The prevalence of dyslexia in Belgium, Britain, Poland, and Greece is comparable with the Netherlands. Other countries (with published prevalence studies) have a different prevalence rate: Slovakia (1-2%); Czech Republic, Norway, Singapore (2-3%); Denmark (3-5%); Italy (1.5-5%); China (4-8%); Japan (6%); USA (8.5%); Russia, Finland, Kenya, and Nigeria (10-11%) (Peer & Reid, 2000; Smythe, Everatt, & Salter, 2004). These differences could be a consequence of real differences but could also be caused by different assessment methods and other assessment problems like inadequacy of existing tests.

Usually, learning to read and spell in a transparent language is easier than in an opaque language (Caravolas, 2005). In a transparent language, the letters and sounds are consistent: with one-to-one grapheme-phoneme (spelling to sound) and phoneme-grapheme (sound to spelling) correspondence (Caravolas, 2005). Although children taught in transparent orthographies learn to read and spell much faster, the prevalence of dyslexia appears to be the same across languages when children learn to read and spell in their mother tongue (Ganshow & Miles, 2000).

In this regard, the comparable prevalence rates of dyslexia in Britain (with an opaque language), Greece (with a transparent language), and the Netherlands (with an intermediate position) confirm the findings of Ganshow and Miles (2000) that prevalence of dyslexia does not depend on the level of transparency of languages. Several findings from cross-linguistic research show the similarity in cognitive profiles of students with dyslexia in a variety of languages; thus, both phonological and naming speed deficits (though at different levels) are present across languages (Caravolas, 2005; Hanley, 2005).

The identification of children at risk for dyslexia is possible with the Dyslexia Screening Test (DST-NL) (Kort et al., 2005). This instrument was developed in England and translated to Dutch. The target age range is 6.5-16.5 years (Fawcett & Nicolson, 2005). The test assesses skills that play a key role in dyslexia: literacy skills, rapid naming, working memory and phonological awareness (Blomert, 2006; Smythe & Everatt, 2000). Despite the large number of immigrant children in Dutch primary education nowadays, there is no reference to them in the DST-NL manual. The present study examines differences in DST (term used for DST-NL in this article) performance by mainstream and immigrant children.

Assessing dyslexia in immigrant children

About 14% of primary school pupils in the Netherlands are immigrant or have at least one immigrant parent (CBS, 2007). Most of them speak their mother tongue at home with their parents and the Dutch language with their siblings and start to learn the Dutch language when they are two years of age and enter nursery school, or when they are four years and enter primary school. (Eldering, 2002; Extra & Yagmur, 2010). The differences in language ability between Dutch (term used here to denote the mainstream group) and immigrant children decrease throughout the school years, but usually do not disappear (Dagevos & Gijberts, 2007; Voortgangsrapportage GOA, 2004).

Fifteen years ago, when there were fewer immigrant children in school, the Dutch language ability of immigrant children was lower than nowadays (Nieuwenhuizen, 2005). In 2005, Turkish and Antillean children were lagging behind 2.5 years in language ability, Moroccan children 2 years, and Surinamese children 1 year at the end of primary school (SCP, WODC, CBS, 2005). Although this lag decreased in fifteen years for 10% of the Turkish and Moroccan children and for 30% of the Surinamese children, still, many immigrant children are lagging behind two years in language ability at the end of primary school (Nieuwenhuizen, 2005).

The prevalence of dyslexia is taken to be the same for mainstream and immigrant children (Wentink & Verhoeven, 2004); yet, it is difficult to recognize dyslexia in multi-lingual children (Peer & Reid, 2000). Cross-cultural research shows that unintentional difficulties of an instrument can have an adverse impact on scores of immigrant children in tests; these factors are referred to as bias (Uiterwijk & Vallen, 2005; Van de Vijver & Leung, 1997). As a consequence, immigrant children could underperform in tests measuring intelligence and school performance (Bleichrodt & Van de Vijver, 2001; Te Nijenhuis & Van der Flier, 1997).

Three types of bias are distinguished in cross-cultural psychology: construct bias, method bias, and item bias (Van de Vijver & Leung, 1997). Construct bias will occur when the construct is not identical across cultural groups. In that case the test does not measure the same concept across cultures (Kouratovsky, 2002). Method bias refers to measurement anomalies in an instrument arising from particular characteristics of the instrument or its administration, such as tester/interviewer effects, communication problems between respondent and tester, or lack of comparability of samples (e.g., differences in educational background, age or gender composition) (Van de Vijver & Leung, 1997). Anomalies at item level are called item bias. Items could be more difficult for one cultural group, than for another, because of item-specific problems, such as inadequate translation or inadequacy of item content in a cultural group. For example, an item about bacon is more difficult for Islamic children (than for Dutch children), because they have less or no contact with it (Resing & Hessels, 2001; Van de Vijver & Leung, 1997).

These problems could also affect the many DST subtests that are verbal, have references to the Dutch culture (Dutch object names, Dutch names), and utilize a time limit. These aspects make it more difficult for immigrant children than for Dutch children (Bleichrodt & Van de Vijver, 2001; Resing & Hessels, 2001). As a consequence, a poor performance by immigrant children may be difficult to interpret: low scores on measures of reading skills, reading, and spelling development by immigrant children could be a consequence of deficient language skills, dyslexia, or assessment problems (Peer & Reid, 2000; Wentink & Verhoeven, 2004).

The present study

The purpose of this study is to detect group differences in DST scores between Dutch and immigrant 8- and 9-year-old fifth-graders to address cultural bias in the instrument. Among these are children with and without dyslexia. Considering the linguistic and cultural character of the DST, construct and item bias could challenge the usefulness of this test. These types of bias are studied in this project. The following hypotheses are tested. First, due to the various sources of bias mentioned, the DST structure in a factor analysis is not expected to be the same for the immigrant group as for the Dutch group (construct bias). Second, lower DST subtest scores and higher dyslexia risk scores are expected in the immigrant group, compared to the Dutch group (construct and item bias).

A lagging word lexicon and lower level of parental education, a proxy of socioeconomic status, are hampering educational opportunity of both Dutch and immigrant children. There is a correlation between children's reading ability and educational level of the parents (Van der Leij, 2003). Therefore, these factors could have a negative influence on test scores (Dagevos et al., 2003). In this line of reasoning, a negative relationship is expected between language ability and the level of parental education and between DST subtest scores (and hence, a higher probability of an assessment as being at risk for dyslexia).

Method

Participants

The DST was administered to 116 children in the fifth year of education, 54% of which were Dutch and 46% immigrant children. The children were aged 8-9 years and children of a second generation, apart from a single exception. At least one of the parents of the immigrant children was born in a non-western country. Most of the immigrant children (64%) were Turkish, 25% were Moroccan, and 11% had other countries of origin, such as Vietnam, Iraq, and countries in East-Europe and Africa. The children came from two different schools, that used the same teaching methods (Taaljournaal, Alles Telt, Estafette, Ondersteboven van Lezen). These schools have a relatively high number of dyslexic children, because of the schools specialty of dyslexia. Particularly Dutch parents of dyslexic children choose these schools for their children.

The immigrant children's language spoken in most homes was the mother tongue. In these homes, Turkish and Tarifit (language spoken by Rif Berbers, the mother tongue of the Moroccan children in this study) were spoken. Turkish is an alphabetic and transparent language. Because of the differences between the transparent mother tongue and the more opaque Dutch language, the reading and spelling ability was compared. No differences in reading and spelling development were found in this population: there were no significant differences between the mean score in reading (CITO DMT) and spelling (CITO LOVS Spelling) between the Dutch and immigrant group. To make it possible to compare the scores, the regular Dutch norm tables of these tests were used for both groups. However, the use of Dutch norms should not be interpreted as indicating that these norms are valid in both groups.

In the Dutch system of school administration, the educational level of the parents (in their home country) is divided in three levels: low (no education or only primary school; 2% of the Dutch parents, 66% of the immigrant parents), middle (primary school and three or four years low level of high school; 14% of the Dutch parents, 17% of the immigrant parents), and high (at least four years middle or high level of high school; 84% of the Dutch parents, 17% of the immigrant parents). Most of the parents of the Dutch children had a high level of education, most parents of the immigrant children had a low level of education.

Measures

The Dutch version of the Dyslexia Screening Test (DST-NL) was administered. The DST-NL has 14 subtests. The risk indicator (called PLQ, Psycho Linguistic Quotient) is based on seven subtests: Rapid Naming Pictures, Rapid Naming Letters, One-Minute Reading, Two-Minutes Spelling, Nonsense Passage Reading, Non-Word Reading, and One-Minute Writing. The other subtests are an indication of memory functioning (Phonemic Segmentation 1 and 2, and Backward Digit Span) and Association (Verbal fluency and Semantic fluency). They are not part of the risk indicator of the DST, but still provide indications of dyslexia (Blomert, 2006).

All subtests were administered, with the exception of Postural Stability and Bead Threading because the subject ‘physical ability’ was left out of this research. The latter subtests have no significant relationship with dyslexia (r = -.11) (Fawcett & Nicolson, 2005) and are not part of the risk indicator in the test. The interpretation of DST scores is straightforward in that lower scores point to a higher risk of having dyslexia. Additional measures were obtained from school records. Scores on a spelling test (CITO LOVS Spelling) and a Word Reading test (CITO DMT), were administered in the middle of the fifth year of education. The CITO LOVS Spelling test starts with a shared part and is followed by two different parts with different difficulties, depending on the score of the first part.

Finally, information about the level of parental education in their mother country and the level of word lexicon were collected from school records. The level of word lexicon is a strong predictor of language ability (Beglar & Hunt, 1999). In our sample, the Word Lexicon school test (CITO LOVS Woordenschat) was administered at the end of the fourth year of education.

Procedure

The DST was administered individually in a quiet room. The three testers were trained in administering the DST. They worked at both schools, two as remedial teachers and one as a psychologist. The Word Lexicon school test, LOVS Spelling and DMT were administered by the teacher in the class or in a separate classroom, during the lessons given by an intern. Data were collected over a period of 4 years (2006-2009).

Results

Descriptives

In this sample, 14% of the Dutch and 6% of the immigrant children were diagnosed with dyslexia (in reading and spelling), by psychologists from different practices outside the school. In this case, this difference was not significant, $\chi^2(1, N = 116) = 2.14$; this means that these numbers suggest that the Dutch and immigrant group did not show a different likelihood of being diagnosed with dyslexia.

Although differences in 'at risk for dyslexia' scores were expected, the difference in the PLQ risk scores between the Dutch (M = 98.9, SD = 15.2) and immigrant children (M = 100.34, SD = 10.77) was not significant ($t = -.58$, $df = 114$, *ns*) in the total group (dyslexic and non-dyslexic). As expected, the level of word lexicon showed differences between both groups. More specifically, the mean of Dutch children (M = 3.87, SD = 1.12) was significantly higher than the mean of the immigrant children (M = 1.73, SD = .84; $t = 11.61$, $df = 111$, $p < .001$). In the same way, the level of parental education was significantly higher for the Dutch (M = 2.86, SD = .35) than for the immigrant children (M = 1.51, SD = .78; $t = 11.77$, $df = 69$, $p < .001$). The total group has a high percentage of Dutch dyslexic children, this could be a consequence of the fact that parents of dyslexic children relatively often send their children to these schools, because these schools are known to pay special attention to dyslexia (despite being regular primary schools).

The correlations between the dyslexia diagnosis (scored dichotomously as present or absent), Word Lexicon, Parental Education, and risk are shown in Table 2.1. Differences between the correlations were tested; the correlations did not differ significantly across the two cultural groups. As could be expected, the PLQ risk indicator correlated positively with a diagnosis of dyslexia in both groups (Dutch children: $r = .49$, $p < .01$; immigrant children $r = .38$, $p < .01$). However, these correlations are not very high. Also as expected, Parental Education correlated significantly with Word Lexicon (.34, $p < .01$) in the Dutch group. On the other hand, there was no significant correlation (.01, *ns*) between Parental Education and Word Lexicon in the immigrant group. Another difference was found in the correlations between Parental Education and having a diagnosis of dyslexia. In the immigrant group, the level of Parental Education correlated significantly with the diagnosis of dyslexia (-.26, $p < .05$), whereas no significant correlation between these variables was found in the Dutch group (-.17, *ns*); yet the difference in the correlations was small. In closer inspection of, the protocols do not suggest any difference in score profiles of Dutch and immigrant children diagnosed of dyslexia.

Table 2.1 *Correlations for the Dutch* (n = 63) *and immigrant group* (n = 53) *(Dutch children below diagonal; immigrant children above diagonal)*

Variable	1	2	3	4
1. Word Lexicon		.01	.11	.12
2. Parental Education	.34**		-.25	-.26*
3. PLQ riska .	20	.01		38**
4. Diagnosis dyslexia	.01	-.17	.49**	

[a]PLQ: psycholinguistic quotient, that represents the risk score based on the screening test.
*$p < .05$. **$p < .01$.

In this research, the internal consistencies of the DST subtests were mostly high and comparable in both groups (Naming Pictures: .77; One-Minute Word Reading: .92; Phonemic Segmentation 1: .64; Phonemic Segmentation 2: .83; One-Minute Writing: .82; Non-Word Reading: .93; One-Minute Writing: .84). The internal consistency of Digit Span Backward was low (.47), which could probably be explained by the small number of items.

It was somewhat unexpected that no significant differences were found in the mean scores in reading (CITO DMT (Dutch norm tables)) and spelling (CITO LOVS Spelling (Dutch norm tables)) between the Dutch and immigrant group. Anyhow, the DST had two subtests to measure the reading and spelling ability: One-Minute Word Reading and Two-Minutes-Spelling. For the total group, a strong correlation was found between the CITO DMT and the DST One-Minute-Word-Reading (.74, $p < .01$) and a weaker, though still significant correlation between the LOVS CITO Spelling and the DST Two-Minutes Spelling (.36, $p <.01$).

When the correlations were computed for the Dutch and immigrant group separately, the same correlations between these reading tests were found in both groups (.74, $p < .01$). Still, the correlations between these spelling tests were not significant for the Dutch group (.30, *ns*) and significant for the immigrant group (.46, $p < .01$).

In a next step, differences in DST (sub)test mean scores were found between the non-dyslexic Dutch and non-dyslexic immigrant children. The non-dyslexic Dutch children scored significant higher on the subtests Naming Letters (Dutch 11.57 versus immigrant 9.32), Verbal Fluency (Dutch 10.77 versus immigrant 9.62), and Semantic Fluency (Dutch 10.57 versus immigrant 8.90). The non-dyslexic immigrant group had a significantly higher mean score on the subtest Non-Word Reading (Dutch 9.42 versus immigrant 10.68). In contrast, no significant differences in DST (sub)test mean scores were found between dyslexic Dutch children and dyslexic immigrant children. As documented below, this pattern of differences replicated those findings in the total group (MANOVA).

Interesting was the difference found in the subtest Naming Letters. This subtest was more difficult for the immigrant group, compared to the Dutch group, as 70% of the Dutch children made no mistakes in naming letters whereas 31% of the immigrant made no mistakes in the same subtest. Most of the errors were made in switching the following letters: naming /f/ as /v/ (20%), naming /v/ as /f/ (8%), naming /s/ as /c/ (23%), naming /c/ as /s/ (11%) and pronunciation errors (12%). The Turkish children made more mistakes than the Dutch and Moroccan children in these errors, except for naming /v/ as /f/, as can be seen in Table 2.2.

Table 2.2 P*ercentages of mistakes in switching letters*

	f named v	v named f	c named s	s named c
Dutch	35%	38%	8%	30%
Turkish	55%	12%	64%	61%
Moroccan	10%	50%	18%	9%

Hypothesis testing

Hypothesis 1: The DST structure in a factor analysis in the immigrant group and the Dutch group are not the same

A Principal Component Analysis was conducted for the two groups separately; the scree plot suggested the extraction of one factor. The first factor explained 47.8% of the variance in the Dutch group and 30.4% of the variance in the immigrant group. Similarity of the factors across groups was assessed using Tucker's Phi. The obtained value of .93 is well above .90, which has been suggested as lower threshold for factorial similarity (Van de Vijver & Leung, 1997). Therefore, we can conclude that the factor structure was equivalent in both groups. Yet, a closer analysis of the differences in loadings (Table 2.3) suggests that there may be some salient differences in factor loadings. We found absolute differences in factor loadings that were larger than .30 for the factor loadings of Naming Letters, Naming Pictures, and Verbal Fluency. Much smaller differences were found for the subtests measuring technical reading skills. Second, we can conclude that, despite the global similarity of the factor across the two groups, Naming Letters and Verbal Fluency are less strongly related whereas Naming Pictures showed a higher loading.

Table 2.3 *Factor loadings, Mean and Standard Deviation of DST scores for the Dutch and immigrant group*

	Factor loading			Dutch		Immigrant	
Subtest	D.	Imm.	Diff.[a]	*M*	*SD*	*M*	*SD*
PsychoLinguistic Quotiënt:							
Naming Pictures	.24	.58	.47	9.67	3.09	9.60	2.88
Naming Letters	.65	.13	-.49	11.21	3.04	9.32	2.69
One-Minute Word Reading	.90	.89	.17	10.14	3.04	9.75	2.52
Two-Minutes Spelling	.89	.73	.00	9.60	2.49	10.25	2.06
Nonsense Passage Reading	.74	.50	-.14	10.14	2.65	10.83	1.57
Non-Word Reading	.85	.85	.18	8.78	2.73	10.38	2.16
One-Minute Writing	.66	.62	.09	9.41	2.79	10.47	2.69
PLQ Risk Score				98.90	15.20	100.34	10.77
Memory functioning:							
Digit Span Backward	.20	.00	-.20	9.67	3.03	10.02	2.37
Phonemic Segmentation 1	.58	.31	-.22	10.29	2.64	9.87	2.33
Phonemic Segmentation 2	.75	.61	-.01	10.06	2.49	9.68	2.05
Association:							
Verbal Fluency	.53	.18	-.31	10.56	3.34	9.60	2.61
Semantic Fluency	.49	.22	-.22	10.40	2.48	8.89	2.07

D = Dutch (mainstream) children. Imm. = Immigrant children. [a]Diff. is the difference in factor loadings between the groups; larger (absolute) values point to larger discrepancies

Hypothesis 2: Lower DST subtest scores and a higher probability of dyslexia risk are expected in the immigrant group than in the Dutch group

The second hypothesis was tested in a MANOVA, with the DST scores and PLQ as dependent variables and culture (Dutch vs. immigrant) as between-subject factor in all analyses. The effect of culture was significant ($F(2, 116) = 7.01$, $p < .001$, (partial) $\eta^2 = .47$). The observed effect size here was large (threshold values for small, medium, and large effect sizes are .01, .06, and .14 respectively, (Cohen, 1988)). The univariate effect of culture was significant for Naming Letters ($F(2, 116) = 12.28$, $p < .001$, $\eta^2 = .10$), Non-Word Reading ($F(2, 116) = 11.90$, $p < .001$, $\eta^2 =$

.10), One-Minute Writing (F(2, 116) = 4.29, $p < .05$, $\eta^2 = .04$), and Semantic Fluency (F(2, 116) = 12.38, $p < .01$, $\eta^2 = .10$). The analysis elaborated the t-test scores before. As can been seen, the effect size of culture on these subtests was between medium and large. So, it can be concluded that the expected differences were found in four subtests of the DST.

In a second analysis, a MANCOVA was conducted, with the DST scores as dependent variables, culture as independent variable, and Word Lexicon as covariate. The analysis tested to what extent Word Lexicon could explain the cross-cultural differences in DST scores. The effect of culture in this analysis was significant and large (F(2, 112) = 2.00, $p < .05$, $\eta^2 = .21$). The effect of Word Lexicon was also significant (F(2, 112) = 2.10, $p < .05$, $\eta^2 = .22$ (large effect)). The subtest Non-Word Reading was still significant (F(2, 112) = 8.43, $p < .01$, $\eta^2 = .07$ (medium effect)), after controlling for Word Lexicon.

The third analysis examined the effect of Parental Education in a MANCOVA with Parental Education as covariate. The effect of culture was still significant (F(2, 116) = 1.91, $p < .05$, $\eta^2 = .20$ (large effect)) after controlling for Parental Education. The effect of Parental Education is not significant (F(2, 116) = 1.36, $p = .20$, $\eta^2 = .15$). The subtest Semantic Fluency was still significant after controlling for Parental Education (F(2, 116) = 4.41, $p < .05$, $\eta^2 = .04$ (between small and medium effect)).

A similar analysis was conducted to test the effect of Word Lexicon and Parental education on DST performance and risk scores; a MANCOVA was carried out with both variables as covariates. This analysis showed that the multivariate effect of culture was not significant after controlling for the covariates (F(2, 112) = 1.08, $p = .39$, $\eta^2 = .13$). In this analysis, the effect of Word Lexicon was significant, but the effect of the level of Parental education was not significant. Before controlling for Word Lexicon there was a significant effect of culture for Naming letters, Non-Word Reading, One-Minute Writing, and Semantic Fluency, whereas after controlling for Word Lexicon there was only a cross-cultural difference in Non-Word Reading, with a higher score for the immigrant children. It is important to note that the subtests Naming Letters, Phonemic Segmentation 1 and 2, Non-Word reading, One-Minute Writing, Verbal and Semantic Fluency showed a decline in effect size between .006 and .09 after controlling for Word Lexicon. However, a small increase in effect size between .005 and .024 was found in One-Minute Word Reading, Two-Minutes Spelling, Digit Span Backward, Nonsense Passage Reading, and PLQ Risk Score after controlling for Word Lexicon. As a result, it can be concluded that different DST scores in the Dutch and immigrant children were found, which confirmed the hypothesis. In this regard, these differences largely disappeared after controlling for Word Lexicon and the level of Parental education, with the exception of Non-Word Reading and One-Minute Writing (the immigrant group had a higher average score on this subtest).

Discussion and Conclusion

The purpose of this study was to investigate the nature and size of cultural group differences in DST scores between immigrant and Dutch children. The differences in DST, found in this study, were in line with our expectation. Word Lexicon and, to a lesser extent the level of Parental Education, can statistically account for the group differences in DST scores. Combining the data of the two groups, it can be concluded that there is presumably a weak negative association between Parental Education and having a dyslexia diagnosis, as expected. However, this correlation is weaker than the correlations between the PLQ at risk score and having a diagnosis, which were significantly correlated in both groups. The correlations between Word Lexicon and having a diagnosis were not significant in any group.

Interesting is the question why the subtests Naming Letters, Naming Pictures, Verbal and Semantic Fluency were relatively strongly affected by the level of Word Lexicon or cultural knowledge. Test observations and an analysis of the scoring protocols pointed to some potential explanations. For example, the immigrant children made more mistakes in naming letters and switched the /s/, /z/, /c/, and /f/ and /v/ more often than the Dutch children. Probably, the Dutch children are also familiar with the letters and letter combinations in the Dutch language, which do not exist in the immigrant children's first language (interference), so it is easier to recognize these letters and combinations for the Dutch children. On the other hand, the effect of negative interference (recognizing /gn/ as /ng/ or /eo/ as /oe/, considering that /ng/ and /oe/ are well known letter combinations in the Dutch language) probably affected the Non-Word Reading scores in the Dutch group, the average score of this subtest was higher for the immigrant group. These differential interference effects, induced by knowledge of another language, are unrelated to dyslexia. Immigrant children are relatively more disadvantaged in the naming tasks and less in the technical tasks. This could be a consequence of differences in sound and name of the letters. For example, in a reading task the /c/ and /s/ sound equal as [s] most of the time, in the naming task they have to be named different as [s] or [c].

Another remarkable difference was noticed during the administration of Naming Pictures and Verbal and Semantic Fluency; the immigrant children needed more time to remember the name of the object or word and improved more than the Dutch children (which takes time). These observations suggest that cultural bias could play a role in the DST, as the problems observed during the test administration, such as switching the letters /s/ and /z/, are probably mainly due to a lower level of mastery of the Dutch lexicon by immigrant children in comparison to Dutch children.

Furthermore, children of this age are visiting mosques for a few years, where they learn to read their mother languages and the Koran. The absence of specific Dutch letters in the mother language or differences in pronunciation of the same letters could be a cause of switching the letters /c/ and /s/ and /f/ and /v/. These findings are in line with earlier cross-cultural research, which showed that unintentional difficulties of an instrument can have a negative influence on scores of immigrant children (Uiterwijk & Vallen, 2005; Van de Vijver & Leung, 1997).

Interference of the first language could also have influenced the test scores in another way; the mother tongue of most immigrant children was transparent (Turkish) whereas Dutch is a more opaque language. Despite these differences, we found no significant differences in the reading and spelling ability between the Dutch and immigrant children. Most of the letters in the subtest Naming Letters were transparent (71%). Opaque letters in the subtest were: /o/, /e/, /i/, /a/, /c/, and /u/. Mistakes in the subtest Naming Letters were made in the opaque letter /c/ and in transparent letters. Thus, transparency could not explain the differences in Naming Letters.

Although Turkish and Moroccan children made more mistakes in the subtest Naming Letters compared to the Dutch children, most of the errors were made by the Turkish children. This finding is not surprising, given the orthographies of the two languages. Many letters are similar in the Dutch and Turkish alphabet; yet, the Turkish alphabet has more letters, for example /c/ and /ç/, /s/ and /ş/, and some Dutch letters do not exist (/w/, /q/ and /x/); finally, there are differences in pronunciation of some letters: the /v/ is pronounced as [w] and /c/ as [dsch]. These sources of confusion do not exist for the Moroccan children. The letters of Arabic are different (Arabic and Latin system), comparing to the Dutch letters, but most of the time, the Moroccan adults and childeren only have a command of the verbal language.

A limitation of this research was the small number of immigrant children with an average or high level of Word Lexicon. This is clearly an issue which requires further research. Probably, there are more immigrant children with an average or high level of word lexicon in the higher grades of primary school, because differences in language ability and word lexicon are known to decrease throughout the school years (Dagevos & Gijsberts, 2007; Voortgangsrapportage GOA, 2004). Unfortunately, because of the small number of the sample size and the small number of dyslexic children in the immigrant group, it was not possible to address clearly the differences in typically developing immigrant children and dyslexic immigrant children and their PLQ scores of being at risk of dyslexia. This is an interesting topic for further research.

The results of this study support the claim that recognizing dyslexia in immigrant children is more difficult compared with Dutch children because of potential bias in instruments to assess dyslexia (Cline, 2000; Peer & Reid, 2000). Screening immigrant children for dyslexia with the DST might be possible if it is acknowledged that the scores of the affected subtests and the coherence between the level of language ability of the child and DST scores are interpreted carefully. Further investigation should reveal if these findings also play a role in other grades of primary school and to what extent further test adaptations would be able to decrease bias problems in the DST.

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Chapter 3

Differences in Neurocognitive Aspects of Dyslexia in Dutch and Immigrant 6-7- and 8-9-Years Old Children

Introduction

Dyslexia is defined as a disorder in reading skills, reading, and spelling development. Dyslexia can affect children's learning possibilities in a negative way, which makes it very important to detect dyslexia as early as possible in the school career. Early assessment and intervention are important issues in research, as these can enable dyslexic children to live in line with their real potential and intelligence. In the present study we want to detect differences between Dutch and immigrant children in neurocognitive aspects of dyslexia, phonologic awareness, rapid naming, and verbal memory (Goswami, 2008), measured with the Dyslexia Screening Test (DST-NL). The purpose of this study is to detect differences in DST scores between 6-7- and 8-9-years old dyslexic and non-dyslexic children, presumably related to the different stage of brain development in reading and spelling area during the development of literacy skills in the two grades. In addition, we set out to identify cultural bias in DST subtests by comparing (dyslexic and non-dyslexic) mainstream Dutch and immigrant children taking into account group differences in level of Word Lexicon.

Literacy development

Oral language, syntax, vocabulary, and phonological processing skills play an important role in early reading development in first- and also second-language learning (Gottardo, Collins, Baciu, & Gebotys, 2008; Share & Stanovich, 1995;

Swanson, Rosston, Gerber, & Solari, 2008). The triangle framework of reading development and visual word recognition (Seidenberg & McClelland, 1989), a widely used theoretical framework of normal development of reading, has guided the development of a variety of connectionist models of reading development (Snowling & Hulme, 2007). According to this model, the development of reading skills depends on the interaction between three aspects of words: their sound (phonology), meaning (semantics), and written form (orthography). Two pathways interact when children learn to read. The phonological pathway relates orthography to phonology (a written word can be translated into its spoken form) and the semantic pathway relates orthography to phonology via semantics (a written word produces direct activation of the meaning of the word, which activates pronunciation) (see Figure 3.1) (Snowling & Hulme, 2007).

In the beginning of reading development, the phonological pathway is often used for letter sound mapping, whereas in a later phase, children rely more on the semantic pathway (Plaut, McClelland, Seidenberg, & Patterson, 1996). Because children make use of sentence contexts in combination with decoding rules to read new words, Share (1995) and Bishop and Snowling (2004) have expanded the model to incorporate interactions between semantic representations and other sources of linguistic knowledge, such as grammar and discourse level processing (see Figure 3.1).

The interaction effect in this model explains why vocabulary knowledge in preschool is one of the predictors of later word-level reading skills and word-reading. Children will have fewer difficulties in learning to read the words that are in their speaking vocabulary in their second language (Catts, Fey, Zhang, & Tomblin, 1999; Elbro, Borstrøm, & Petersen, 1998; Metsala & Walley, 1998).

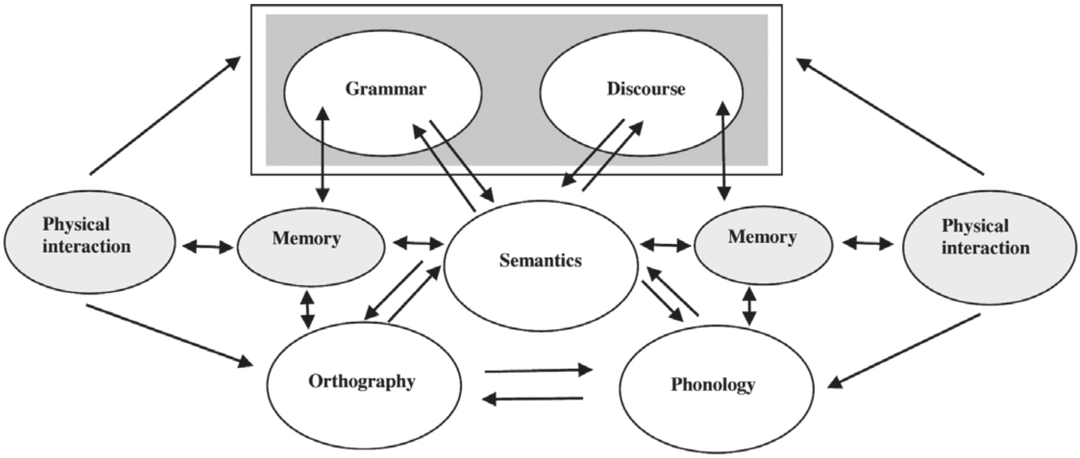

Figure 3.1 The triangle framework of reading development (after Seidenberg and McClelland 1989; Bishop and Snowling 2004 for the dark grey part) and recent findings from Glenberg et al. (2009), Marley et al.(2011), and Wellsby and Pexman (2014) added (light gray part)

A small vocabulary knowledge can restrict the number of words available for recognition (Nation & Snowling, 1998). Dutch third grade children (6-7 years old) have on average a vocabulary knowledge between 4500 and 5200 words. Turkish and Moroccan children achieve this level of vocabulary knowledge when they are nine years old (in the fifth grade of education) (Kuiken & Vermeer, 2005; Verhoeven & Vermeer, 1991). Ethnic minority children need two years to develop peer-appropriate communicative language, but between five and seven years to fully develop academic language proficiency (Cummins, 1984). A small vocabulary can hamper reading comprehension. Such children cannot consistently index or map written words to the objects the words represent, they can fail to derive meaning to the text. Reading becomes, in this case, more an exercise in 'word calling' (Glenberg, Gutierrez, & Levin, 2004). Glenberg et al. (2004, 2011) showed with a set of experiments that manipulation with toys of the story can enhance young children's reading performance, as reflected by both their memory for what they have read and their ability to derive text-based inferences. Learning strategies targeted at developing receptive and productive language skills are positively associated with children's reading achievement (see Elleman, Lindo, Morphy, & Compton, 2009, for an overview). Recent embodiment theories are based on principles that cognitive development depends on physical interaction with the environment and physical interaction with objects associated with a symbolic representation (Glenberg & Robertson, 2000; Glenberg, 2011; Ramus, 2003; Wellsby & Pexman, 2014). Recent studies show that embodied effects can also be observed in children's reading comprehension, to make reading comprehension fast and automatic by linking written words to sensorimotor experience, which is called 'moved by reading' (Glenberg, Goldberg, & Zhu, 2009). These recent findings are added to Figure 3.1 to complete this figure.

Another significant predictor of reading and spelling proficiency in an alphabetic script is phonological awareness (Bialystok, 2006; Ziegler & Goswami, 2005). Phonological awareness is defined as the ability to recognize, identify, or manipulate any phonological unit within a word, be it phoneme, rhyme, or syllable (Zieger & Goswami, 2005). In bilinguals, phonological awareness predicts the levels of reading proficiency in each language (Durgunoğlu, Nagy, & Hancin-Bhatt, 1993). Phonological awareness of children with different language backgrounds develops in a similar manner (Chiappe, Siegel, & Gottardo, 2002). Research showed that phonological awareness is a skill that is not restricted to the first language and that appears to transfer to one's second language (Cisero & Royer, 1995; Durgonoğlu et al., 1993; Pang, 2009; Verhoeven, 1994). Young children, who are learning English as a second language, performed less well than native English speakers on tasks measuring phonological awareness in kindergarten, but these differences tend to disappear in the first year of formal schooling, when they are taught sound-letter correspondences (Chiappe et al., 2002). Chiappe et al. (2002) found that the same underlying skills, alphabetic knowledge, spelling, and phonological processing, were strongly related to literacy acquisition in a second language for children with another linguistic background. These findings support the importance of word lexicon and oral language in the development of reading and spelling. Lindsey, Manis, and Bailey (2003) showed that the rate of change of bilingual children's language ability in both languages predict their letter-word identification abilities in both languages.

Literacy in a second language

In Europe, migration is one of the main factors of bilingualism and language change (Tabouret-Keller, 2006). In the Netherlands, 20% of the population has at least one foreign-born parent (9% in a Western country and 11% in a non-Western country) (CBS, 2011). In the past, residents of former Dutch colonies migrated to the Netherlands, including immigrants from Indonesia (1950s), the Dutch Antilles, and Aruba (1960s). In the same period (1950s), male guest workers were recruited from Southern Europe for factory work in Western European countries and later (1960s) from Turkey and Morocco (Backus, 2006). Political and religious refugees from former East Bloc countries (1970s) and former Yugoslavia (1980s) formed the major source of migration. After family reunification and family formation (after 1980s), a second generation is now well established and a third generation is coming of age (Backus, 2006). Present-day migrants are seeking work, better living conditions, and freedom. Most of them come from Turkey, Northern Africa, the former Yugoslavia and various Eastern European countries (such as Poland and Bulgaria), Asia, and the US (Tabouret-Keller, 2006). Nowadays, about 12 - 14% of primary school pupils in the Netherlands are immigrant or have at least one immigrant parent (CBS, 2007; Statistics Netherlands, 2014). The educational achievements of notably non-Western immigrant children are below those of Dutch mainstream children; in addition, relatively few students enter forms of higher education (Backus, 2006; CBS, 2007). A low level of proficiency in the majority language and sociocultural factors are often related to poor linguistic and scholastic results (Backus, 2006; Hamers & Blanc, 2000). Bilingual children and young adults generally have weaker receptive vocabulary knowledge in each language than their monolingual peers (Oller, Pearson, & Cobo-Lewis, 2007; Portocarrero, Burright, & Donovich, 2007). Most of the immigrant children tend to grow up in a context that is monolingual or dominated by one language, which is the native language of the parents. The mother tongue input decreases when 4-years-old children move into a much more majority language dominated world when they start kindergarten and school (Pfaff, 1999). The dominance of the minority language often changes in a majority language dominance after the age of 8 in children of the second and third generation (Akinci, Jisa, & Kern, 2001; Pfaff, 1999). Children of the second and third generation often speak the mother tongue with their parents and the majority language with their siblings, and friends at that age (Backus, 2006).

When children learn their first language (mother tongue), they develop a growing knowledge of the world into their continually widening vocabulary, based on their experience and create a system of words and meanings, concepts and symbols, that is core to their intelligence (Bialystok, 2001; Smith, 2013). Development means learning both concepts to structure the world and words to label and express those structures. Words and concepts do not exist in isolation, but they are organized in networks and are referred to as the “deep structure” of our understanding (Marzano, 2004). Bilingual children have different language learning experiences, different cognitive worlds, and are challenged to communicate using different resources (Bialystok, 2001). The intellectual path to literacy develops in three stages. The first is the preliteracy stage in which children build up concepts of symbolic representation and learning about the writing system. Bilingual children develop these background concepts differently from monolingual children because of differences in their social, linguistic, and cognitive world (Bialystok, 2001; Dale, Crain-Thoreson, & Robinson, 1995). They develop these background concepts for learning to read separately for their two languages, depending on their experience with each (Bialystok, 2001).

The second is the stage of early learning in which children learn the rules for decoding the written system into the familiar sounds of the spoken language. The first step in an alphabetic script is to learn mapping visual symbols (letters) to units of sounds (phonemes). Differences in reading development are explained by differences in orthography. In some orthographies (e.g., Greek, Italian, Turkish, Spanish, and German), letters and letter clusters are almost always spelled and pronounced in the same way (transparent). In other writing systems (e.g., English, Danish, and French), letters and letter clusters can have multiple pronunciations and phonemes can have multiple spellings (opaque) (Malloy & Botzakis, 2005). The Dutch language is less transparent than Greek and Turkish, but more transparent than English, Danish, and French (Seymour, Aro, Erskine, 2003). See Figure 3.2 for an overview of transparency of diverse languages. The process of learning these mappings is called phonological recoding (Ziegler & Goswami, 2005).

Children learn to find shared grain sizes in the symbol system (orthography) and phonology of their language to learn accurate mapping (Goswami, Ziegler, &

Grapheme-to-phoneme correspondence	Language
Transparent/Shallow (in this study level 4)	Finnish Japanese Turkish Indonesian Czech
Rather transparent (in this study level 3)	Surinamese Japanese Somali Serbo-Croatian Persian Bulgarian Spanish Italian Greek German Polish Croatian Romanian
Rather opaque (in this study level 2)	Ethiopic Farsi Pashto Portuguese Dutch Swedish Polish
Opaque/Deep (in this study level 1)	Arabic Berber/Tarifit* French English Hebrew Chinese Danish

Figure 3.2 Level of transparency of diverse languages Based on: Brunswick (2010), Seymour et al. (2003), Smythe et al. (2004) and Perfetti & Dunlap (2008)
**Note: Tarifit and Berber were in origin oral languages but are nowadays also written and educated at school since 2002 (www.meertaligheidentaalstoornissenvu.wikispaces.com)*

Richardson, 2005; Ziegler & Goswami, 2005). Learning to read and spell is easier in a transparent language than in an opaque language (Malloy & Botzakis, 2005). A more opaque language like English has a lower mapping consistency at the grapheme-phoneme level, which leads to more variability in the size of grapheme units that need to be combined in the orthography to phonology mappings. Readers in opaque languages like English need to use a larger part (grain size) of the printed word to map onto spoken language, whereas the process of decoding a word letter by letter (small grain size) is more adequate in transparent languages like Turkish (Ziegler & Goswami, 2005). In this view, the relationship between vocabulary and reading development should be stronger in less consistent orthographies, where vocabulary can play an important role in recognition of words and parts of words (Ziegler & Goswami, 2005). This can be an advantage for bilingual children if their two languages differ in transparency. When children learn the less transparent system, they can profit from this experience in learning the more transparent system of their first language (small grain size strategy) (Bialystok, 2001).

The third stage is fluent reading. In this stage, the meaning of the text takes priority and children can begin to use written texts for receiving and expressing ideas, they did not have before (Bialystok, 2001). Research showed that the ability in reading fluency in a second language can be predicted by different factors, such as the level of proficiency in the first language (Cummins, 1991), the level of proficiency in the second language (Barnett, 1989), and the knowledge of cultural schemata and discourse structures of the second language (Barnitz, 1986; Carrell, 1994; McCardle, Miller, Ren Lee, & Tzeng, 2011). Individual differences in reading ability in monolingual and bilingual children are also influenced by reading experience: the more children read, the more skilled they become in reading (Stanovich, 1986).

Dyslexia

Dyslexia has been found in all languages in which it has been studied (for a review, see Smythe, Everatt, & Salter, 2004). Cross-cultural differences in manifestation are presumably caused by two critical factors: phonological complexity and orthographic transparency of the languages involved (Goswami, 2008). There is agreement that children with dyslexia have not developed well-specified phonological representations of the sound structure of the individual words in their mental lexicon (Snowling, 2000). These children have difficulties in three kinds of phonological tasks: phonological awareness tasks (e.g., the tapping task and the oddity task), phonological short term memory tasks (digit span), and rapid automatized naming tasks (e.g., naming pictures and naming letters) (Goswami, 2008). These difficulties are found in various languages, such as Chinese (Ho, Law, & Ng, 2000), Japanese (Kobayashi, Kato, Haynes, Macaruso, & Hook, 2003), English (Bradley & Bryant, 1978), and German (Wimmer, 1993) (see Ziegler et al., 2010, for a recent overview).

For children with dyslexia who are learning to read transparent orthographies it is easier to develop the necessary decoding skills than for dyslexic children who are learning to read an opaque language. The impairment in reading speed in dyslexic children means that these children are functionally dyslexic, even if decoding is relatively accurate (Goswami, 2008; Ziegler et al., 2010).

Dyslexia and the brain

Neuroimaging studies show that universal networks for language are left-lateralized to the frontal and temporal areas of the brain of speakers of all languages. For reading, neural networks also seem to be left-lateralized, comprising a network of frontal, temporoparietal, and occipitotemporal regions (Goswami, 2008). Learning to read requires associating sounds with letters and the process of automatization of this ability (Haaxma, 2006). The starting reader reads by decoding every single letter, a process which takes place in the gyrus angularis and the Broca area. Turkeltaub, Gareau, Flowers, Zeffiro, and Eden (2003) found an increase in activity in left temporal and frontal areas in normal reading development, while activity in right posterior areas declined. This pattern shows the possibility that reading-related activity in the brain becomes more left-lateralized with development. Turkeltaub et al. (2003) explored the neural activation associated with phonological awareness. They found that the degree of activity in the left posterior superior temporal cortex and inferior frontal gyrus depended on the level of children's phonological skills. Analyses of children below 9 years old identified also the left posterior superior temporal cortex suggesting that the route for reading is phonological recoding to sound (Turkeltaub et al., 2003). In this view, it is possible that the 6-7 years old children score different on the DST reading, spelling, and phonological tasks than 8-9 years old children.

In fMRI studies, Shaywitz et al. (2002) showed that children with developmental dyslexia showed underactivation in the core brain areas for reading, namely the left frontal, temporal, parietal, and occipital sites, during reading-related tasks (letter identification, single letter rhyme, and nonword rhyming). During these tasks, the right-hemisphere sites, largely in the temporoparietal cortex, were activated by the children with developmental dyslexia (Nicolson & Fawcett, 2008; Shaywitz et al., 2002). The role of the cerebellum in automatization was described by Leiner, Leiner, & Dow, (1989). Recent findings confirmed, in the context of dyslexia, the significance of specific cerebellar activation in reading (Fulbright et al., 1999; see Nicolson & Fawcett, 2008 for an overview; Turkeltaub, Eden, Jones, &

Zeffiro, 2002) and working memory (Desmond & Fiez, 1998). Nicolson and Fawcett (2008) proposed that cerebellar abnormality from birth leads to slight speech output dysfluency and receptive speech problems (i.e., difficulties in analyzing the speech sounds), and hence to deficiencies in phonological awareness (Nicolson, Fawcett, & Dean, 2001). Taken together with the cerebellar impairment, this analysis could account for the development and pattern of difficulties of dyslexic children.

Dyslexia in the Netherlands

The age at which children, after a period of kindergarten, begin formal schooling and start with learning to read and spell differs per country. In United Kingdom, formal schooling begins at the age of 5 years (Goulandris, 2003), Dutch, Greek, Polish, and American children start at 6 years (Nikolopoulos, Goulandris, & Snowling, 2003; Szczerbiński, 2003) and children in Germany, Austria, and the Scandinavian countries start when they are 7 years of age (Seymour, 2007). Dutch schoolchildren start to learn phonological sensitivity, reading skills, and letter-sound correspondence in the first year of education, at the age of four (kindergarten). In the third grade (the first year of formal schooling after two years of kindergarten), they start to learn to read and spell. Every school in the Netherlands has to check the reading and spelling development of its pupils and to identify children at risk for dyslexia.

A well known instrument for identifying children at risk for dyslexia is the Dyslexia Screening Test (DST-NL) (Kort et al., 2005). This instrument was developed in England and translated to Dutch. The target age range is 6.5-16.5 years (Fawcett & Nicolson, 2005). The DST (term used for DST-NL in this article) assesses skills that play an important role in dyslexia: literacy skills, rapid naming, working memory, phonological awareness, reading ability, and spelling ability.

Many subtests of the DST are verbal and have references to the Dutch culture (e.g., Dutch names). These characteristics could affect the immigrant children's test scores on the DST. When these children start to learn to read in the third grade, they have less experience with the Dutch culture and language. During the years of schooling, vocabulary growth and experience with the Dutch way of education and testing will increase, which will have a positive effect on DST scores. Research shows that the Rapid Naming Pictures, Rapid Naming Letters, and Verbal Fluency subtests of the DST are relatively difficult for 8- and 9-years old immigrant children, probably because of the linguistic and cultural character of these subtests (Verpalen & Van de Vijver, 2011). Group differences in performance disappeared after statistically controlling for the level of word lexicon (Verpalen & Van de Vijver, 2011).

In the Netherlands, the same prevalence of dyslexia has been reported among Dutch (term used here to denote the mainstream group) and immigrant children (Wentink & Verhoeven, 2004). Yet, it is difficult to recognize dyslexia in multilingual children and they are under-represented among children assessed as dyslexic (Cline, 2000; Peer & Reid, 2000). When immigrant children enter schooling, their knowledge of the Dutch language and culture is often limited (Verhoeven, 2000). Although differences in language ability between Dutch and immigrant children tend to decrease throughout the school years, they do not disappear (Dagevos & Gijsberts, 2007; Voortgangsrapportage GOA, 2004). Turkish and Antillean immigrant children are on average still lagging behind two and a half years in language ability at the end of primary school (after eight years of education), Moroccan children two years and Surinamese children one year (Nieuwenhuizen, 2005).

Another cause of differences in test scores between Dutch and immigrant children are unintentional difficulties of an instrument, which can have an adverse impact on scores of immigrant children. These factors are referred to as bias (Van de Vijver & Leung, 1997). In cross-cultural psychology, three types of bias are distinguished: construct bias, method bias, and item bias (Van de Vijver & Leung, 1997). There is construct bias when the test does not measure the same concept across cultures. Method bias refers to measurement anomalies in an instrument arising from particular characteristics of the instrument or its administration, such as tester/interviewer effects, communication problems between respondent and tester, or lack of comparability of samples. Item bias refers to item-specific problems, such as inadequate translation or inadequacy of item content in a cultural group. An item about bacon was more difficult for Islamic children than for Dutch children, because they have less or no contact with it (Resing & Hessels, 2001; Van de Vijver & Leung, 1997).

Current study

In this study we aim to detect group differences in DST scores between Dutch and immigrant and between third and fifth graders to address cultural bias in the instrument and to get more insight in the association of development in reading and spelling skills on DST test scores in learning a first and second language. Construct and item bias could challenge the usefulness of the DST, because of the linguistic and cultural character of the DST. Differences in vocabulary knowledge and cultural knowledge between Dutch and immigrant children decrease throughout the school years; so, a decreasing performance gap between immigrant and Dutch children's DST scores is expected across the period of schooling. This effect is also expected because of the switch in language dominance of minority in majority language after the age of 8 (Akinci et al., 2001; Pfaff, 1999), the brain development activity in left temporal and frontal areas in normal reading development and the increase in using the semantic pathway in the fluent reading stage, as described in the introduction. The following hypotheses are tested: Differences in DST scores are expected between the non-dyslexic third and fifth graders in both (Dutch and immigrant group) groups and between the dyslexic third and fifth graders in both ethnic groups because of development in literacy skills related to the development in brain activity. Second, lower DST subtest scores and higher dyslexia risk scores are expected in the immigrant group, compared to the Dutch group (construct and item bias could play a role) and these intergroup differences are smaller in the third grade than in the fifth grade, because of the increased level of word lexicon in the fifth grade and the switch in language dominance at the age of 8.

Method

Participants

The DST was administered to 125 children in the third year of education (33% Dutch, 67% immigrant) and to 149 children in the fifth year of education (47% Dutch, 53% immigrant). Most of the children of the classes were taking part in this research; a few children did not take part as parents did not give permission for participation. The children were aged 6-7 years (third grade) and 8-9 years (fifth grade), respectively. All participants followed the regular school program of their grade and had sufficient language knowledge for the test administration. In the group of immigrant children, at least one of the parents was foreign born, in most cases in a non-western country. Almost all children were second generation; 44% of the immigrant children were Turkish, 33% were Moroccan, and 23% had other countries of origin, such as Iraq, Vietnam, Indonesia, Surinam, and countries in Eastern Europe and Africa. The children were from two different schools with the same teaching methods for education in reading, language, and mathematics. Both schools have a relatively high number of dyslexic children, because the schools specialize in dyslexia care in the curriculum. Dutch parents therefore often choose these schools for their children in case of (suspected) dyslexia in their children. A total of 15% were diagnosed with dyslexia (in reading and spelling) of whom 56% were Dutch children and 44% were immigrant children. This means that 21% of the Dutch group and 11% of the immigrant group were dyslexic. The assessment was conducted by psychologists from different centers outside the school using a comprehensive test battery according to the official Dutch dyslexia protocol (Blomert, 2006). The test battery measures dyslexia indications (reading ability, spelling ability, phonological awareness, rapid naming, and verbal short term memory).

Many immigrant children speak the (ethnic) mother tongue of the parents at home or a mix of mother tongue (with their parents) and Dutch (with their siblings). The various home languages have different levels of transparency (see Figure 3.2). In this study, 46.2% of the immigrant children speak a home language with a very high level of transparency (e.g., Turkish, Indonesian, Japanese), 12% a home language with an intermediate level of transparency (e.g., Surinamese, Serbo-Croatian, Somali, Vietnamese), 9% speak a semi-low transparent home language (e.g., Portuguese, Polish, Ethiopic, Farsi, Pashto), and 33% speak an opaque (deep) language at home (e.g., Arabic, Berber or Tarifit, Chinese, French, English).

Most of the immigrant participants of this research did not have good Dutch vocabulary knowledge. The level of Dutch vocabulary knowledge (assessed in the same school test on both schools) was divided in five classification groups, based on the standardized scores across grades: very low, low, average, above average, and

Table 3.1 *Number and percentage of children of the total group per level of Word Lexicon*

	Group			
	Dutch		Immigrant	
Level of Word Lexicon	3rd graders (n = 46)	5th graders (n = 71)	3rd graders (n = 84)	5th graders (n = 81)
Very low (1)	1 (2%)	2 (3%)	46 (54%)	35 (44%)
Low (2)	4 (9%)	6 (8%)	16 (19%)	23 (28%)
Average (3)	11 (26%)	18 (25%)	12 (14%)	12 (15%)
Above average (4)	6 (14%)	9 (27%)	5 (6%)	7 (9%)
High (5)	21 (49%)	26 (37%)	6 (7%)	3 (4%)

high. In an ANOVA, with culture and grade as fixed factors and Word Lexicon as dependent variable, the effect of culture on Word Lexicon between the Dutch and immigrant third and fifth graders was significant ($F(3, 268) = 173.57$, $p < .001$, $\eta^2 = .39$), the effect of grade was not significant for Word Lexicon ($F(3, 268) = .005$, $p = .96$). As can been seen in Table 3.1, the Dutch group obtained higher scores. Because of these differences, word lexicon was used as covariate in the analyses, to study the effect of word lexicon on DST scores.

The educational level in the home country of the parents is divided in three groups: low (no education or only primary school), middle (primary school and three years low level of high school), and high (at least four years of middle or high school). In this study, 2% of the Dutch and 54% of the immigrant parents had a low educational level, 13% Dutch and 12% immigrant parents had a middle educational level and 85% Dutch and 34% immigrant parents had a high educational level. The difference in the level of education of the parents of the Dutch and immigrant children was significant, $\chi^2(2, N = 325) = 100.67$, $p < .001$). Because of these differences, level of education of the parents was used as covariate in the analyses.

Measures

The Dutch version of the Dyslexia Screening Test (DST) was administered. The DST has 14 subtests. The DST is a screening test with the purpose to detect children at risk for having dyslexia. After the screening, further research is necessary to diagnose the at-risk children as dyslexic. The interpretation of DST scores is straightforward in that lower scores point to a higher risk of having dyslexia. The risk indicator (called PLQ, Psycho-Linguistic Quotient, see Table 3.2) is based on seven subtests: Rapid Naming Pictures, Rapid Naming Letters, One-Minute Reading, Two-Minutes Spelling, Nonsense Passage Reading, Non-Word Reading, and One-Minute Writing. The other subtests are an indication of memory functioning (Phonemic Segmentation 1 and 2, and Backward Digit Span, see Table 3.2) and Association (Verbal fluency and Semantic fluency, see Table 3.2). They are not part of the risk indicator of the DST, but still provide indications of dyslexia (Blomert, 2006). All subtests were administered, with the exception of Physical Ability (Postural Stability and Bead Threading), because Fawcett and Nicolson (2005) reported no significant relationship between Physical Ability and dyslexia.

The spelling, reading, and vocabulary scores were obtained from school records. Scores on the spelling test (CITO LOVS Spelling), word reading test (CITO LOVS DMT), and word lexicon school test (CITO LOVS Word lexicon) were administered in both schools in January, the middle of the third and fifth year of education. Information about the level of parental education in their mother country was collected from school records. A *Reading School Test (CITO LOVS DMT)* was administered individually, in a separate room during the lessons given by an intern. Children have to read as many words as possible in one minute. In the *Spelling school test (CITO LOVS Spelling)* children have to write words, read aloud by the

Table 3.2 *DST subtests*

DST Factor	Subtest names	Description
Psycholinguistic Quotient (PLQ)		
	Rapid naming Pictures	The child has to name correctly and rapidly as possible the name of 50 pictures (5 different objects: chair, tree, duck, knife and bicycle)
	Rapid naming Letters	The child has to name 50 letters as correctly and rapidly as possible
	One-Minute Reading	The child has to read 24 one syllable words, 24 two syllable words and 24 three syllable words as correctly and quickly as possible
	Two-Minutes Spelling	The child has to spell as many words as possible in two Minutes correctly and quickly as possible. The number of correctly spelled words in two minutes is the score of the test
	Nonsense Passage Reading	The child has to read aloud, as correctly and quickly as possible a passage that have 10 nonsense words mixed into the sentences of real words
	Non-Word Reading	The child has to read 24 one syllable non-words, 24 two syllable non-words and 24 three non-words as correctly and quickly as possible
	One-Minute Writing	The child has to correctly copy a passage (length is age dependent) as quickly as possible
Memory Function		
	Phonemic Segmentation	The child has to segment words into basic sounds and manipulate these words by deleting a letter in a word (Segmentation 1) and switch the first letters of the first name and second name of Dutch famous persons (Phonemic Segmentation 2)
	Backward Digit Span	Series of spoken digits are presented to the child. The Child has to repeat the sequence in backward order
Association		
	Verbal Fluency	In one minute, the child has to mention as many names of words as possible starting with the letter S. The score is the number of correctly mentioned Dutch words
	Semantic Fluency	In one minute, the child has to mention as many names of animals as possible. The score is the number of mentioned animals

teacher. The test starts with a shared part and is followed by two different parts with different difficulties, depending on the score of the first part. A *Word lexicon school test (CITO LOVS Word lexicon)* measures passive word lexicon, children have to choose the correct meaning of a word from four descriptions of the word.

Procedure

The DST was administered individually in a quiet room. Three testers were trained in administering the DST. They worked at both schools, two as a remedial teacher and one as a psychologist. The reading, spelling, and word lexicon school tests were administered by the teacher in the class. Data were collected over a period of 6 years (2006-2011).

Results

Hypothesis testing

In a MANOVA with culture (Dutch vs. immigrant), diagnosis (non-dyslexic vs. dyslexic), and grade (third or fifth grade) as fixed factors and the school test scores for Reading, Spelling, and Word Lexicon (divided in five classification groups, based on the standardized scores across grades: the levels 1 (very low) till 5 (high) for every grade separately) as dependent variables, the multivariate effect of grade was significant, Wilks' $\Lambda = .75$, ($F(16, 242) = 5.11$, $p < .001$, (partial) $\eta^2 = .25$), which refers to a large effect. We used threshold values for small, medium, and large sizes of .01 (small), .06 (medium), and .14 (large) (Cohen, 1988). Univariate tests revealed that the observed effect size on the Spelling school test was significant ($F(1, 257)$, $p < .005$, $\eta^2 = .05$. The mean score of the third grade (3.70) was larger than the mean score of the fifth grade (3.15) (see Table 3.3). There was no significant effect of grade on the reading school test scores and word lexicon. There was a multivariate significant effect of the dyslexia diagnosis, Wilks' $\Lambda = .64$, $F(16, 242) = 8.43$, $p < .001$, $\eta^2 = .36$. The univariate tests revealed that the observed effect size on the

Table 3.3 *Standardized mean scores Dutch non-dyslexic and dyslexic third and fifth graders and immigrant non dyslexic and dyslexic third and fifth graders*

	Dutch				*Immigrant*			
	3rd graders		*5th graders*		*3rd graders*		*5th graders*	
	Non-dyslexic	*Dyslexic*	*Non-dyslexic*	*Dyslexic*	*Non-dyslexic*	*Dyslexic*	*Non-dyslexic*	*Dyslexic*
Naming Pictures	10.28	9.33	9.70	8.71	9.28	8.56	9.57	7.78
Naming Letters	11.56	9.22	11.68	9.93	11.15	9.00	9.53	8.67
One-Min. Reading	9.19	4.67	10.84	6.29	8.20	4.78	9.66	6.67
Phon. Segment. 1	10.00	8.78	10.63	8.64	9.29	8.78	9.56	8.33
Phon. Segment. 2	9.91	8.78	10.54	7.71	9.08	9.00	9.33	7.78
Two-Min. Spelling	10.63	8.11	10.16	7.07	9.63	8.78	10.01	8.56
Backw. Digit Span	9.50	8.11	9.66	9.36	8.79	9.00	9.70	11.22
Nons. Pass. Reading	10.22	7.89	10.71	8.07	9.79	8.33	10.49	7.56
Non-Word Reading	9.50	5.67	9.48	5.21	8.95	6.78	10.26	5.33
One-Minute Writing	11.19	9.00	10.11	7.29	10.35	8.89	10.27	8.67
Verbal Fluency	10.97	7.89	11.00	9.21	10.40	11.00	10.01	11.11
Semantic Fluency	10.84	10.33	10.64	9.71	9.09	9.67	9.09	9.11
PLQ	103.25	83.89	102.63	82.14	97.64	85.22	99.71	83.56
Reading school test	3.69	2.22	4.16	2.00	3.55	1.56	3.83	2.00
Spelling school test	3.94	2.67	3.53	1.62	3.78	3.22	3.29	2.11
Word Lexicon school test	3.91	4.11	3.98	3.46	1.95	1.89	1.91	2.56

Reading school test scores was large ($F(1, 257) = 95.84$, $p < .001$, $\eta^2 = .27$), with a higher mean score (see Table 3.3) for the non-dyslexic group (3.75) than the dyslexic group (1.95). The effect size was also large for the Spelling school test scores ($F(1, 257) = 36.69$, $p < .001$, $\eta^2 = .13$), with also a higher mean score (Table 3.3) for the non-dyslexic group (3.60) compared to the dyslexic group (2.32). There was no significant effect of the dyslexia diagnosis on word lexicon. The multivariate effect of culture was significant, Wilks' $\Lambda = .68$, $F(16, 242) = 7.20$, $p < .001$, $\eta^2 = .32$. The univariate tests revealed that (only) the observed effect size on word lexicon was large ($F(1, 257) = 75.10$, $p < .001$, $\eta^2 = .23$). The mean score (Table 3.3) of the Dutch children (3.90) was higher than the mean score of the immigrant children (1.96).

A significant interaction effect was found between grade and diagnosis, Wilks' $\Lambda = .90$, $F(16, 242) = 1.78$, $p < .05$, $\eta^2 = .11$. The univariate tests revealed that the observed effect size was significant, yet small ($F(1, 257) = 5.06$, $p < .05$, $\eta^2 = .02$) for Phonemic Segmentation 1 and also small ($F(1, 257) = 4.29$, $p < .05$, $\eta^2 = .02$) for

Non-Word Reading. The mean scores (see Table 3.3) on Phonemic Segmentation 1 of the non-dyslexic children (9.35) and the dyslexic children (8.89) in the third grade were lower than the mean scores of the non-dyslexic children (9.88) and dyslexic children (7.86) in the fifth grade. The non-dyslexic third graders (9.20) scored lower than the non-dyslexic fifth graders (10.00) on Non-Word reading, and the dyslexic third graders (6.22) scored higher than the dyslexic fifth graders (5.33) on Non-Word Reading.

The other interaction effects were not significant (between grade and culture: Wilks' $\Lambda = .94$, $F(16, 242) = .94$, $p = .53$, $\eta^2 = .06$; between culture and diagnosis: Wilks' $\Lambda = .92$, $F(16, 242) = 1.27$, $p = .22$, $\eta^2 = .08$; between grade, culture, and diagnosis: Wilks' $\Lambda = .95$, $F(16, 242) = .87$, $p = .61$, $\eta^2 = .05$). In sum, we found significant multivariate effects of grade (on the Spelling school test), dyslexia diagnosis (on the Reading school test and Spelling school test), and culture (on Word Lexicon) and an interaction effect between grade and dyslexia diagnosis on Phonemic Segmentation 1 and Non-Word Reading.

It could be argued that the previous MANOVA did not consider covariates that could potentially account for existing cultural differences. We addressed the influence of two relevant confounding variables in the next analysis: the level of parental education and word lexicon. We conducted a MANCOVA, with the total group (third and fifth graders), and culture (Dutch vs. immigrant), diagnosis (non-dyslexic vs. dyslexic), and grade (tested in the third or fifth grade) as fixed factor and the standardized scores on each DST subtest and PLQ as dependent variables and the effect of parental education and word lexicon as covariates. This analysis tested to what extent word lexicon and level of parental education could explain the cross-cultural differences in DST scores. In the MANCOVA, the multivariate effect of word lexicon (Wilks' $\Lambda = .87$, $F(13, 250) = 2.99$, $p < .001$, $\eta^2 = .14$), grade (Wilks' $\Lambda = .80$, $F(13, 250) = 4.71$, $p < .001$, $\eta^2 = .20$), culture (Wilks' $\Lambda = .90$, $F(13, 250) = 2.08$, $p < .05$, $\eta^2 = .10$), and diagnosis (Wilks' $\Lambda = .74$, $F(13, 250) = 6.91$, $p < .001$, $\eta^2 = .26$) were significant. However, the multivariate effect of parental education was not significant, Wilks' $\Lambda = .95$, $F(13, 250) = 1.08$, $p = .38$, $\eta^2 = .05$. The multivariate effect of the interaction between grade and having a diagnosis was significant, Wilks' $\Lambda = .91$, $F(13, 250) = 1.83$, $p < .05$, $\eta^2 = .09$, which refers to a medium effect size. The multivariate interaction between grade and culture was not significant, Wilks' $\Lambda = .96$, $F(13, 250) = .90$, $p = .55$, $\eta^2 = .05$, and the effect of interaction between culture and having a diagnosis was not significant, Wilks' $\Lambda = .95$, $F(13, 250) = 1.06$, $p = .39$, $\eta^2 = .05$. The effect of the interaction between grade, culture, and having a diagnosis was not significant, Wilks' $\Lambda = .97$, $F(13, 250) = .64$, $p = .82$, $\eta^2 = .03$.

A significant, yet small effect of culture was found on Naming letters (see Table 3.4) before controlling for word lexicon and parental education. There was also a significant effect of culture found on Semantic Fluency, which was small. After controlling for word lexicon and the level of education of the parents, there was a significant, small effect of culture on Backward Digit Span and Verbal Fluency. After controlling for word lexicon and level of education of the parents, the effect of culture was no longer significant for the subtests Naming Letters and Semantic Fluency. The effect of grade was significant for One-Minute Reading and Backward Digit Span. The effect of having a dyslexia diagnosis was significant for Naming Letters, Naming Pictures, One-Minute Reading, Phonemic Segmentation 1, Phonemic Segmentation 2, Two-Minutes Spelling, Nonsense Passage Reading, Non-Word Reading, One Minute Reading, and for the PLQ. The effect of grade on One-Minute Reading and Backward Digit Span was still significant after controlling for word lexicon and the level of education of the parents.

As can been seen in Table 3.4, the effect size of having a dyslexia diagnosis is between small and medium for the subtests Naming Pictures, Naming Letters, and Phonemic Segmentation 1, medium for the subtest Phonemic Segmentation 2, between medium and large for the subtest Two-Minutes Spelling and Nonsense Passage Reading, and large for One-Minute Reading, Non-Word Reading, and the PLQ (Table 3.4). In all cases dyslexia was associated with lower performance. The effect of having a dyslexia diagnosis on the DST subtests showed a similar pattern after controlling for word lexicon and educational level of the parents, the effect of having a dyslexia diagnosis had a significant effect on the same subtests with a comparable weight (see Table 3.4), with the exception Naming Pictures, the effect of a dyslexia diagnosis was no longer significant in the MANCOVA, although the reduction in effect size was very modest. Differences in mean scores between the third and fifth grade were found on One-Minute Reading (effect between small and medium) and Backward Digit Span (small effect).

In a third analysis, involving only the immigrant group a MANCOVA was conducted to evaluate the effect of the level of transparency in the home language. In the MANCOVA with diagnosis (non-dyslexic vs. dyslexic), and grade (tested in the third or fifth grade) as fixed factor and the standardized scores on each DST subtest and PLQ as dependent variables and the effect of parental education and word lexicon as covariates, the level of transparency was added as covariate too. The multivariate effect of the level of transparency of the home language was not significant, Wilks'Λ = .93, F (13, 153) = .88, p = .57, η^2 = .07. There was only a significant effect, between small and medium, of transparency of the home language found on the subtest Naming Letters (F (3, 168) = 4.83, η^2 = .03, p = .03).

Table 3.4 *Multivariate Analysis of Variance of culture, grade and diagnosis, before and after correcting for the effect of word lexicon and educational level of the parents as covariates (total group)*

	Culture		*Grade*		*Diagnosis*	
	Correction		*Correction*		*Correction*	
DST subtest	*Before*	*After*	*Before*	*After*	*Before*	*After*
Naming Pictures	.01	.01	.00	.00	.02*	.01
Naming letters	.02*	.00	.00	.00	.05***	.05***
One-Min. Reading	.00	.00	.04***	.04***	.18***	.18***
Phon. Segment. 1	.01	.00	.00	.00	.03**	.03**
Phon. Segment. 2	.01	.00	.00	.00	.06***	.06***
Two-Min. Spelling	.00	.01	.00	.00	.10***	.09***
Backw. Digit Span	.00	.03**	.02*	.01*	.00	.00
Nons. Pass. Reading	.00	.00	.00	.00	.13***	.12***
Non-Word Reading	.00	.00	.00	.00	.27***	.24***
One-Minute Writing	.00	.00	.01	.01	.08***	.07***
Verbal Fluency	.01	.02**	.00	.00	.01	.01
Semantic Fluency	.03**	.00	.00	.00	.00	.00
PLQ	.00	.00	.00	.00	.18***	.16***

*p<.05. **p<.01. ***p<.001.

Because of the significant interaction effect between grade and having a diagnosis, mean differences in the DST scores between the non-dyslexic and dyslexic children in the third and fifth grade separately, were further analyzed in a set of *t* tests. In the third group, the non-dyslexics scored significantly higher on seven subtests and the PLQ (Table 3.5), with a small effect size on Phonemic Segmentation 2, a medium effect size on Two-Minutes Spelling and One-Minute Writing and a large effect size on Naming Letters, One-Minute Word Reading, Nonsense Passage Reading, Non-Word Reading, and the PLQ compared to

Table 3.5 *Differences in mean scores DST subtests between non-dyslexic and dyslexic third and fifth graders*

	Third grade			Fifth grade		
Subtest	Non-dyslexic	Dyslexic	*d*	Non-dyslexic	Dyslexic	*d*
Naming Pictures	9.58	8.94	.22	9.63	8.35	.41*
Naming Letters	11.27	9.11	.76**	10.48	9.43	.36
One-Min. Reading	8.50	4.72	1.39***	10.18	6.43	1.68***
Phon. Segmentation 1	9.50	8.78	.29	10.03	8.52	.61*
Phon. Segmentation 2	9.33	8.89	.35*	9.87	7.74	.90***
Two-Minutes Spelling	9.93	8.44	.71**	10.08	7.65	1.38***
Backward Digit Span	9.00	9.06	-.02	9.68	10.09	-.14
Nons. Passage Reading	9.92	8.11	.95**	10.59	7.87	1.19***
Non-Word Reading	9.11	6.22	1.30***	9.91	5.26	2.20***
One-Minute Writing	10.60	8.94	.63*	10.20	7.83	.89***
Verbal Fluency	10.57	9.44	.31	10.45	9.96	.15
Semantic Fluency	9.62	10.00	-.14	9.78	9.48	.13
PLQ	99.32	84.56	1.16***	101.10	82.70	1.48***

*$p<.05$, **$p<.01$, ***$p<.001$.

their dyslexic classmates (Cohen's *d* values for small, medium, and large sizes: 0.2 (small), 0.5 (medium), and 0.8 (large); Cohen, 1988). In the fifth grade, the non-dyslexic children scored significant higher on eight subtests and the PLQ, with a small effect size on Naming Pictures, a medium effect size on Phonemic Segmentation 1, and a large effect size on One Minute Reading, Phonemic Segmentation 2, Two Minute Spelling, Nonsense Passage Reading, Non-Word Reading, One Minute Writing, and the PLQ (see Table 3.5), compared to their dyslexic classmates. As can be seen in the table, the large effect of a dyslexia diagnosis on Naming Letters in the third grade is no longer significant in the fifth grade. In contrast to the third grade there was a significant small effect of a dyslexia diagnosis on Naming Pictures and a medium effect on Phonemic Segmentation 1 in the fifth grade. An increase of effect sizes in the fifth grade was found in One-Minute Word Reading, Phonemic Segmentation 2, Two-Minutes Spelling, Nonsense Passage. Rea-ding, Non-Word Reading, One-Minute Writing, and the PLQ (Table

3.5). In sum, the differences in DST scores and the PLQ increased between the third and fifth grade.

In summary, differences in DST scores between the non-dyslexic and dyslexic third and fifth graders (Dutch and immigrant) (hypothesis 1) were found in both groups. We found a significant effect of having a dyslexia diagnosis in the Dutch and immigrant group. Noticeable is the interaction between diagnosis and grade. The score differences between the dyslexic and reference group increased with grade. Contrary to our expectation, a significant effect of culture on DST subtests scores and the PLQ was only found on a few subtests and the effects were small: Naming Pictures and Semantic Fluency before controlling for Word Lexicon and Educational Level of the parents and Backward Digit Span and Verbal Fluency after controlling for Word Lexicon and Educational level of the parents (hypothesis 2). There was no significant interaction between culture and grade, we did not find a decrease of cultural differences from the third to the fifth grade (hypothesis 2).

Discussion

The purpose of this study was to detect differences in neurocognitive aspects of dyslexia in Dutch and immigrant 6-7- and 8-9-years-old children, with the expectation that more differences would be found in the third grade (6-7-years-old children) than in the fifth grade (8-9-years old children). These expectations were based on the presumed development of reading and spelling skills between the third and fifth grade, the language development of the immigrant children during the period of schooling between the third and fifth grade, development of brain activity during reading and spelling tasks, bias in the screening test or dyslexia assessment and other assessment difficulties. However, in this research, we found the opposite;

the differences between non-dyslexic and dyslexic children increased with grade, the lag in development increased in both dyslexic Dutch and immigrant children. When dyslexia is diagnosed, the difficulties develop in a comparable way for Dutch and immigrant children, which is in line with the notion that phonological awareness, phonological short term memory, and rapid automatized naming are universal predictors of dyslexia (Chiappe et al., 2002; Goswami, 2008; Snowling, 2000; Ziegler et al., 2010), which are represented in the DST. These data are compatible with the view that dyslexia is a neurodevelopmental disorder with a salient genetic component. Paulesu et al. (2001) showed a universal neurocognitive basis for dyslexia across languages. The aim of their study was to contrast dyslexic and normal readers in deep (English and French) and shallow (transparent) (Italian) orthographies in order to explore similarities and differences at the cognitive and brain level, or both. At the cognitive level, the usual pattern was found: the Italian, English, and French dyslexic group performed more poorly on the phonological short-term memory (digit span, digit symbol), phonological tasks and reading tasks, compared to the control non-dyslexic group. The Italian group differed strongly from their control group (Italian non-dyslexics) on nonword reading, but performed better on the nonword reading task when compared to the French and English dyslexic groups. The phonological impairment in dyslexics supports the idea that dyslexia is associated with a phonological deficit that is independent of orthography (Paulesu et al. 2001), which is confirmed in this study. At brain level, reduced activation has been found in the left middle, inferior, and superior temporal cortex and in the middle occipital gyrus in all three language groups. These results suggest that dyslexia has a universal basis in the brain and can, independent of the orthography, be characterized by the same neurocognitive deficit (Paulesu et al. 2001). It seems that the expected differences (differences in phonological tasks and literacy skills between Dutch and immigrant third and fifth graders) were not found because of the universal basis of brain activity and that the Dutch language, reading, and spelling skills develop in the same way when immigrant children start schooling in the Netherlands from the first grade.

The effect of culture on DST scores was limited. Small differences in the effect of culture before and after controlling for word lexicon and parental education were found in the subtests Naming Letters, Backward Digit Span, and Verbal and Semantic Fluency. These subtests have a very linguistic character, which could be associated with bias. Further research could make this clear. Probably, the development of reading, spelling, and the phonological skills develop in the same way in Dutch and immigrant children, during the schooling period from the first to the fifth grade. The technical character of these skills, which are taught in the educational program from the start, could be an explanation why training effects are similar for both groups. When immigrant children start their Dutch education at the first grade, they follow the same training of these skills as the Dutch children, with probably the same effects. Further research could make clear if there are differences between children with Dutch schooling from the first grade and children who started later with Dutch education, when they arrived in the Netherlands at an older age. Still, the level of word lexicon has a correlation with several subtests: in the third grade on the subtests Phonemic Segmentation 1 and 2 and Backward Digit Span and in the fifth grade on the subtests One-Minute Reading, Phonemic Segmentation 1 and 2, Backward Digit Span, Verbal Fluency, and Semantic Fluency and could have an important influence on the DST scores from immigrant children, in view of their lower scores on the Word Lexicon school test. Recent reading models, with an influence of sensorimotor experience on language development (see Figure 3.2), especially on semantic knowledge, could also play a role in the development and ability of language skills and, related to this: reading comprehension and reading fluency, semantic fluency, and naming fluency. Further research could explore this link.

In this research, the immigrant children scored lower on the word lexicon school test (in both, raw scores and standardized scores across grades as a classification of the level of Word Lexicon) than the Dutch children in the third grade. We expected higher raw Word Lexicon scores in the fifth grade, in such an extent that they reach a higher level of word lexicon classification. However, the raw scores increased in both group, Dutch and immigrant, but not enough for the immigrant group to reach a higher level of word lexicon in standardized scores. The differences in standardized Word Lexicon scores between the third and fifth grade was nil, in both (Dutch and immigrant) groups, both groups stayed in the same classification of standardized level of word lexicon, the differences between the Dutch and immigrant group (see Table 3.1) did not disappear in two years of education (between the third and fifth grade). The immigrants did not make up for their backlog in word lexicon, in contrast with our expectation and, because of this, the immigrant fifth graders could not profit in DST scores by a higher word lexicon level, which could be an explanation of the limited differences between immigrant third and fifth graders.

Differences between the third (total group) and fifth grade (total group) of this research were found for the dyslexic children. Probably, the DST has a better screening effect in the fifth grade, because there are more significant dyslexia indications with a larger effect found in the fifth grade. Screening of dyslexia seems easier in the fifth grade, differences are clearer, maybe because differences in phonemic awareness, verbal memory, and rapid naming are clearer. Dyslexic children show a slower development than their non-dyslexic peers. Further research can show the effect of screening for dyslexia with the DST in a higher grade, for example the seventh or eighth grade.

A limitation of this research was the small number of dyslexic children and the small number of immigrant children with a high level of word lexicon. This is an issue which requires further research. A larger group of immigrant children makes it possible to examine the influence of different mother tongue like Arabic, Tarifit (language spoken by Rif Berbers, the mother tongue of the Moroccan children in this study), and Turkish.

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Chapter 4

Bias in Dyslexia Screening in a Dutch Multicultural Population

Introduction

Many dyslexia screening and assessment tools have been developed to detect literacy difficulties in monolingual children. In Dutch education, the tests are used to identify children with literacy problems, probably caused by dyslexia. Such children then can get further assessment, possibly followed by special treatment for dyslexics, which can enhance school outcomes in various domains, such as academic, vocational, and personal (e.g., self-esteem) (Loykens, Ruijssenaars, Bron, & Van Mameren-Schoehuizen, 2010; Scott, Sherman, & Phillips, 1992). These screening tests are increasingly used in multilingual school populations. Notably in a non-western immigrant context where home and school language are different, extant tests and test procedures can lead to disadvantages and incorrect classifications in these immigrant groups (Everatt, Ocampo, Veii, Nenopoulou, Smythe, Al Mannai, & Elbeheri, 2010). In the Netherlands, the prevalence of Dutch (majority group) children with dyslexia is about 5%. The same prevalence has been reported for non-western immigrant children (Wentink & Verhoeven, 2004); yet, in the assessment of the latter group, there is a potential problem of misidentification (false positives and false negatives), because it is difficult to recognize dyslexia in children from ethnic groups in which the testing language is not the mother tongue (Cline, 2000; Peer & Reid, 2000). Differences in test scores between Dutch and immigrant children could be a consequence of the groups' differential knowledge of the Dutch language, unintentional difficulties of an instrument, and family-related factors that impinge on school achievement, such as low socioeconomic status and parental support

(O'Bryon, 2014). The purpose of this research is to study the possibility to make a reasonable case for bias in the Dyslexia Screening Test (DST-NL) and examine the role effect of schooling and aging on DST-NL performance in mainstream and non-western immigrant Dutch children. We tried to identify which tasks were at risk for bias and studied the effect of aging and schooling on biased tasks. Dutch children start their education in the first and second grade of kindergarten where some occasional teaching takes place; teaching at a larger scale starts in the third grade when children are six years of age. In this study, which uses a combination of cross-sectional and longitudinal data, we studied the DST-NL subtests and total test score for the plausibility of the presence of bias in the third, fifth, and seventh grade and the effect of schooling and development on DST-NL scores.

Cultural bias

Fairness in assessment is an issue in diverse groups of children. Unintentional cultural factors can influence the way children interpret test items and respond to them. These factors with an adverse impact on test scores of usually immigrant children are referred to as bias (Solano-Flores, 2011; Van de Vijver & Leung, 1997). The presence of cultural specificity in a test or test item could introduce bias.
The stronger the cultural specificity of a test or test item, the larger the likelihood of the items are biased against those outside the majority culture. For example, in a test of crystallized knowledge the test item 'Who was the first president of the United States?' could represent a biased item that favors European-American children and could be more difficult for an immigrant child from Paraguay (Reynolds & Brown, 1984). In cross-cultural psychology three types of bias have been distinguished: construct bias, method bias, and item bias (Van de Vijver & Leung, 1997; Van de

Vijver & Poortinga, 2005). Construct bias occurs if the construct measured is not identical across cultural groups or if there is an incomplete overlap of indicators associated with the construct across cultural groups (e.g., poor sampling of all relevant behaviors or differential appropriateness of the behaviors associated with the construct or incomplete coverage of the construct). Another type of bias is called method bias. Method bias refers to measurement anomalies that are related to the administration of an instrument (differential familiarity with stimulus materials or response procedures, differences in environmental administration conditions, incomparability of samples caused by differences in education or other background characteristics) (Van de Vijver & Leung, 1997; Van de Vijver & Poortinga, 2005). The third type of bias, item bias or Differential Item Functioning, refers to anomalies at item level, caused by poor item translation or inadequacy of item content in a cultural group (Van de Vijver & Leung, 1997; Van de Vijver & Poortinga, 2005). An item about bacon was more difficult for Islamic children than for Dutch children, because they have less or no contact with it (Van de Vijver & Leung, 1997). Culture, language, age, education, socioeconomic status, and acculturation can all play an important role in test performance (O'Bryon, 2014), especially when tests measure a language-related construct, such as learning disability or dyslexia.

Language

Many tests and assessments depend on language in their administration (instructions, item contents, and response procedures). Language proficiency is often not the target of assessment although it may influence the test results (Trumbull & Solano-Flores, 2011). A limited proficiency in the majority language makes the assessment procedure more difficult for immigrant children. Low performance of immigrant children may be due to a lack of understanding of the language of the test rather than a lack of content knowledge. Immigrant children have a dual challenge, because they have to develop their majority language skills and they have to learn the academic content of the curriculum in the majority language (Abedi, 2011; Hakuta, Butler, & Witt, 2000).

Differences between monolinguals (majority group members) and immigrant children tend to be larger on verbal fluency tests than on letter fluency tests (Gollan, Montoya, & Werner, 2002; Verpalen & Van de Vijver, 2011); moreover, immigrant children have a smaller vocabulary size in the mainstream language (Hamers & Blanc, 2000), recognize fewer difficult vocabulary words, and have more tip-of-the-tongue (just-cannot-remember-the-word) retrieval failures than monolinguals (Gollan & Brown, 2006). They also name pictures slower than monolinguals and name fewer pictures correctly on standardized naming tests (Gollan & Brown, 2006; Roberts, Garcia, Desrochers, & Hernandez, 2002; Verpalen & Van de Vijver, 2011). These disadvantages are also present when bilinguals are tested in their first language (Ivanova & Costa, 2008). Developing a majority language and particularly the academic register of the majority language as a second language takes much effort from five to seven years and usually even after that period (Abedi, 2011; Hakuta, Butler, & Witt, 2000).

Sociocognitive factors

In Europe and the United States, migration is a major factor in bilingualism (O'Bryon, 2014; Tabouret-Keller, 2006). Poor linguistic and scholastic results of immigrants tend to be related with a low level of proficiency in the majority language and less favorable sociocultural factors (Backus, 2013; Hamers & Blanc, 2000;

O'Bryon, 2014). In the Netherlands, 21% of the population has at least one foreign-born parent (9% in a Western country and 12% in a non-Western country) (Statistics Netherlands, 2014). The educational achievements of non-Western immigrant children are below those of Dutch mainstream children, fewer students enter forms of higher education but an increase in the percentage of non-Western immigrant children entering higher levels of secondary and tertiary education is reported in the Netherlands for the last ten years (Backus, 2013; Statistics Netherlands, 2007, 2012). Compared to their mainstream peers, non-Western immigrant children are more likely to grow up in families with low levels of education, to live in an unstable neighborhood and in relative poverty which could harm their academic achievement (O'Bryon, 2014; Statistics Netherlands, 2014). Research with Arabic immigrant children in the United States and Russian-Jewish immigrant children in Israel showed that the level of parental education before immigration and their socioeconomic status after immigration play a larger role in the child's successful second language development than the parents' second language proficiency (Kenny, 1996; Schwartz, 2012; Schwartz, Kozminsky, & Leikin, 2009). In the Netherlands, a small association was found between parental education in the home country and immigrant children's reading ability (Onderwijsraad, 2013).

Reading and literacy development in bilingual children

Progress in acquiring literacy in the majority language by immigrant children depends on social, political, and educational factors, the child's exposure to the majority language and academic culture, and on literacy skills and experience developed in their first language, if their mother tongue has a script. Success of early literacy acquisition is related to the value attached to literacy at home and the level of literacy support in the home environment (Cobo-Lewis, Pearson, Eilers, & Umbel, 2002; Francis, 2012; Verhoeven & Durgunoğlu, 1998).

Immigrant children whose mother tongue is a minority language need to learn literacy skills in the majority, second language, which they often do not speak well, notably in the early schooling years (Bialystok, 2001). In this situation, the cognitive skills associated with literacy are being learned at the same time as the linguistic system that is encoded in writing. Reading development has some universal components across languages. When children learn to read, they have to recognize which language elements are encoded in the writing system (the general mapping principle), and deduce exactly how these elements are encoded (the mapping details). These skills and knowledge do not involve language-specific aspects, such as specific language elements or sounds, but universal principles, such as mapping a sound to a symbol.

When these skills are developed in one language, they are available and functional for development in another language (Koda, 2008). Knowing how to read in the first language can facilitate literacy development in the second language (Bialystok, 2001) as children can transfer their skills and knowledge to literacy in a new language (Cisero & Royer, 1995; Durgunoğlu, Nagy, & Hancin-Bhatt, 1993; Gottardo et al., 2001; Verhoeven, 1994). Children's progress in literacy can be adversely influenced by a lack of age-appropriate competence and academic skills in either their first language or second language, which impedes the development of the cognitive systems needed to function academically (Cisero & Royer, 1995; Durgunoğlu et al., 1993; Gottardo et al., 2001; Verhoeven, 1994). Literacy skills can only progress with second-language proficiency, which is influenced by training in the language (contact hours in the second language). Learning a second language with a different script from the first language or when the mother tongue has no script at all, can affect the progress at least initially if literacy development in the second language starts later (Barlett, 2001). As a consequence, dyslexia screening tests could be least useful when the role of assessment is most important: for early identification to start specific treatment and early intervention. On the other hand, recent studies showed also a growing evidence of a weak relationship between the word-based reading process in the second language (the technical skill, and not the comprehension skill) and the oral second language proficiency. Durunoğlu et al. (1993) showed that, unlike oral language, phonological skills predicted technical reading skills (word recognition and pseudo word reading). Other studies with children with different writing systems as first language showed also weak relationships between the proficiency in the second language and word recognition and pseudo-word reading (Geva & Clifton, 1993; Geva & Siegel, 2000; Gholamain & Geva, 1999). In line with these findings, Geva (2000) reported that when children have been exposed to literacy instruction, there is no reason to assume that they are not able to decode words, even when their second language proficiency is still developing.

Assessing literacy skills in immigrant children

The educational home environment, language, and literacy ability, poverty, and parental education of mainstream and immigrant children are often different. A specific group of immigrants, such as refugee children, could have no, limited, or disrupted schooling and experience with food scarcity, displacement, and traumas. These factors can contribute to immigrants' underachievement in reading and spelling (Ehntholt, Smith, & Yule, 2005; Limbos & Geva, 2001; Pollard-Durodola, Cárdenas-Hagan, & Tong, 2014). Underachievement makes it difficult to distinguish between immigrant children who are developing normally with basic weaknesses in their language abilities and immigrant children who are experiencing reading failure (Geva, 2000). This ambiguity can lead to a 'wait-and-see' approach in schools because standardized assessment measures typically do not indicate to what extent low test scores of immigrants are an indication of low reading achievement or language and learning difficulties due to their different background (Chiappe, Siegel & Gottardo, 2002; Gersten & Baker, 2003). Research showed that oral language proficiency only plays a marginal role in reading skills (Durunoğlu et al., 1993; Geva, 2000; Geva & Clifton, 1993; Geva & Siegel, 2000; Gholamain & Geva, 1999). Next to these findings, the development of phonological awareness skills and related processes like naming speed and auditory memory, orthographic knowledge, and speed of lexical access are strongly related to individual differences in word reading skills, which presumably are universal cognitive and linguistic factors that can predict reading ability in both the first and second language (Durgunoğlu et al., 1993; Geva, 2000; Geva & Siegel, 2000). Phonological awareness is the ability to reflect upon and manipulate phonological units in a language (Kuo & Anderson, 2008). Children with dyslexia have reading and spelling problems but they also experience difficulties with phonological tasks, phonological short term memory tasks, and rapid automatized naming tasks (Blomert, 2006; Goswami, 2008). Two of the best indicators of early reading problems and dyslexia in both the first and second language are deficits in phonological awareness and rapid naming (Limbos & Geva, 2001; Paulesu et al., 2001). These indicators are assessed in most of the dyslexia screening tests, also in the Dutch Dyslexia Screening Test as explained below.

Present study: Bias in the Dyslexia Screening Test NL

Dyslexia assessment is possible in young children, a lot of dyslexia indicators become manifest before the child learns to read. Recent studies showed that young preschool children who later developed dyslexia, showed difficulties in pre-literacy skills such as phonological awareness and letter knowledge in preschool which predict later reading ability (Elbro & Petersen, 2004; Regtvoort & Van der Leij, 2007; Van Otterloo, Van der Leij, & Henrichs, 2009). The Dyslexia Screening Test (Dutch version: DST-NL) is a well-known instrument for identifying children at risk for dyslexia (Kort et al., 2005). The DST- NL is a screening test; an 'at risk score', derived from an administration of the test, indicates that the presence of dyslexia might be the underlying problem of literacy difficulties. Full assessment (with additional tests) of such 'at risk' children is necessary to diagnose dyslexia (Kort et al., 2005). The DST-NL is a Dutch instrument, translated from English, with a target age range from 6.5 to 16.5 years (Fawcett & Nicolson, 2005). The English edition was published in 1996 and revised in 2004. In the 1996 version, the phonological tasks were not part of the 'at risk score' (named PLQ in this version). The revised edition is divided in two versions: the DST-Junior for primary school aged children (6.6 to 11.5 years) and DST-Secondary for secondary school-aged children (11.6 to 16.5 years). Two subtests are added to each version (Rhyme and Vocabulary for primary school, Spoonerisms and Non-Verbal Reasoning for secondary school). In the new edition the phonological tasks are part of the 'at risk score' (called ARQ in the new edition), in contrast to the older edition, which decision is in line with the important role of phonological awareness deficits in detecting dyslexia (Blomert, 2006; Goswami, 2008; NRD, 2013). The Dutch edition is a translation of the first edition of the English DST, normed in a Dutch population. There is no translation of the new edition available in the Netherlands. We followed the 1996/2004 recommendation not to include the tests in the PLQ score, although, as shown below, we also addressed their suitability for assessment in multicultural populations. The DST-NL assesses skills that play an important role in dyslexia: literacy skills, rapid naming, working memory, phonological awareness, reading ability, and spelling ability. Many verbal subtests of the DST-NL have references to the Dutch culture (e.g., Dutch names) and could be more difficult for immigrant children, even the rapid naming and verbal fluency tests as described in the introduction.

For our study we also had the outcome of the Dutch dyslexia protocol (NRD, 2013) available. In this protocol, the dyslexia criteria are described and instruments for assessment are advised in its addition. Following this protocol, the child must have very heavy reading problems (percentile score < 10) or heavy reading difficulties (percentile score < 16) combined with very heavy spelling problems (percentile score < 10) and two of more very low scores (percentile score < 10) on the dyslexia indications accurateness and speed of phonological processing, speed and accurateness of sound-letter mapping, and speed of naming digits and/or numbers to diagnose a child as dyslexic (NRD, 2013). We cannot rule out that the dyslexia protocol is susceptible to the same cultural bias as the DST-NL. As a consequence, there is no golden standard against which to evaluate these measures. For the purpose of the analysis, we used the dyslexia protocol scores as validity standard, because using the protocol as (fallible) standard against which the DST can be compared allows the use of various tools such as sensitivity and specificity analysis, which allow for a study of the convergence of the DST-NL and dyslexia protocol outcomes.

In this study we tried to examine to what extent it is possible to detect Dutch and immigrant children at risk for dyslexia with the same instrument (DST-NL) and tried to make a reasonable case for the decrease of cultural bias in the DST-NL for immigrant children across the third, fifth, and seventh grade, taking into account the differences in stage of reading development per grade. The stages are derived from the triangle framework of normal reading development and visual word recognition (Seidenberg & McClelland, 1989), complemented by more recent findings from Bishop and Snowling (2004), Glenberg, Goldberg and Zhu (2009), Marley et al. (2011) and Wellsby and Pexman (2014) (see Verpalen & Van de Vijver, 2015, for a more elaborate explanation of this framework). These stages are useful for monolingual and bilingual children if they started education at least in preschool or kindergarten (the first grade in the Netherlands). In the third grade the child is a starting reader using letter-sound mapping (via the phonological pathway), in the fifth grade the child uses more word recognizing skills with direct activation of the meaning of the word via the semantic pathway. This grade often coincides with a switch in language dominance from the mother tongue to the majority second language, which is generally claimed after the age of 8 to characterize immigrant children who were exposed to the second language at the age of about 2 (e.g., when they started kindergarten) (Akinci, Jisa, & Kern, 2001). In the seventh grade the children tend to be fluent readers (using the semantic pathway).

We used a combined cross-sectional and longitudinal design in which a subsample is assessed twice (third and fifth or fifth and seventh grade) or thrice (third, fifth, and seventh grade). The development in vocabulary knowledge and cultural knowledge could have a positive effect on DST-NL scores throughout the school years. Dyslexia was independently assessed by psychologists using a comprehensive test battery according to the official Dutch protocol (Blomert, 2006;

NRD, 2013). To clarify the role of cultural bias in dyslexia screening tasks, the following hypotheses are tested: first, the prediction of dyslexia diagnosis using the DST-NL subtests and therefore the DST-NL risk score is less accurate for immigrant children in the third, fifth, and seventh grade than for Dutch children in the same grades (due to method and item bias). Immigrant children's underachievement can make it more difficult to interpret the test scores, with more false positives as a consequence. Second, the convergence between the accuracy of the prediction of the DST-NL subtests scores and therefore the DST-NL risk score and the dyslexia protocol outcomes increases throughout the years of schooling for the immigrant children. Third, the verbal subtests of the DST-NL are more difficult for immigrant children in the third, fifth, and seventh grade, even after controlling for the level of Word Lexicon, Parental Education, and the grade of first assessment (cultural bias).

Method

Participants

This study is part of a larger project. In 2006 data collection started in the fifth grade for the first study. Between 2008 and 2013, children of the third, fifth, and seventh grade were assessed for the second and current study. In these seven years, the cohort was enlarged and changed. As a consequence, shifts occurred in the school populations from which we recruited. Some children of the first and second study, who were originally in the non-dyslexic group were diagnosed as dyslexic and added to the dyslexic group (and deleted from the non-dyslexic group) of the current study; some children were diagnosed with low intelligence or weak memory function and deleted from the cohort in the fifth or seventh grade; some children moved to another country or district; finally, some children moved into the district of the schools of this cohort and were added to the third, fifth, or seventh grade. The main reasons for attrition were relocation within the Netherlands and remigration. In one of the participating schools the sample size increased because of a merger with another school, where the DST-NL was not administered before.

The DST-NL was administered to 324 (145 Dutch and 179 immigrant) children in a period of seven years (169 boys and 155 girls). Data were available of 128 children of the third grade (43 Dutch and 85 immigrant children), 244 children of the fifth grade (97 Dutch and 147 immigrant children), and 201 children of the seventh grade (98 Dutch and 103 immigrant children). The children were from two different locations of the school using the same teaching methods for education in reading, language, and mathematics. The locations differ in population (Location A had 11.6% Dutch children and 88.4% immigrant children in the period of data collection and location B 69% Dutch and 31% immigrant children). In a MANOVA with Location (Location A vs. B) and Cultural Background (mainstream vs. immigrant) as fixed factors and the scores on the Reading and Spelling school test per grade as dependent variables, the multivariate effect of School, Cultural Background, and the interaction between Location and Cultural Background were not significant. Univariate tests revealed that the observed effect of Location was significant for Spelling in the third and fifth grade with an effect between small and medium (an effect size of .01 is called small, .06 medium, and .14 large in line with Cohen, 1988) in the third grade ($F(3, 179) = 5.61$, $p < .05$, $\eta^2 = .03$) and fifth grade ($F(3, 179) = 7.29$, $p < .05$, $\eta^2 = .02$), with higher mean scores of location B (with a large number of Dutch children) (see Table 4.1). The effect of Location was not significant for Spelling in the seventh grade. The effect of Location was not significant for the Reading test in the third, fifth, and seventh grade. The effect of

Table 4.1 *Differences in standardized mean scores reading and spelling test per grade and school between Location A and Location B*

	3rd grade						5th grade						7th grade					
	Location A (n = 84)		Location B (n = 99)				Location A (n = 84)		Location B (n = 99)				Location A (n = 84)		Location B (n = 99)			
	M	*SD*	*M*	*SD*	*F*	η^2	*M*	*SD*	*M*	*SD*	*F*	η^2	*M*	*SD*	*M*	*SD*	*F*	η^2
Reading School Test	3.79	1.25	3.90	1.18	.40	.00	3.65	1.24	3.66	1.28	.00	.00	4.04	1.29	3.91	1.33	.42	.00
Spelling School Test	3.63	1.13	4.10	1.03	8.71	.05**	2.98	1.27	3.35	1.35	3.75	.02*	3.60	1.21	3.68	1.07	.23	.00

* $p < .05$, ** $p < .01$

Cultural Background was not significant at all. The interaction between Location and Cultural Background was significant for Reading in the fifth grade ($F(3, 179) = 13.77$, $p < .05$, $\eta^2 = .05$) and the seventh grade ($F(3, 179) = 10.18$, $p < .05$, $\eta^2 = .03$) with both an effect between small and medium and higher mean scores for location B (with a large number of Dutch children).

In the Dutch third grade, the children were aged 6-7 years, in the fifth grade 8-9 years, and in the seventh grade 10-11 years. Almost all immigrant children were second or third generation, 44% of the immigrant children were Turkish, 33% were Moroccan, and 23% had other countries of origin (such as Iraq, Vietnam, Indonesia, Brazil, various countries in Eastern-Europe and in Africa). A small number of them were refugees. Almost all immigrant children had started education at the age of two (preschool) or four (kindergarten). Twenty-one percent of the Dutch and 11% of the immigrant participants were diagnosed with dyslexia in reading and spelling by psychologists from different centers outside the school. The used test battery measures dyslexia indications (reading ability, spelling ability, phonological awareness, and rapid naming), according to the official Dutch dyslexia protocol (Blomert, 2006) and the accompanying cut-off criteria (NRD, 2013). Although recent studies showed that some dyslexics had also verbal short term and working memory difficulties (Durgunoğlu, Nagy, & Hancin-Bhatt, 1993; Geva, 2000; Geva & Siegel, 2000; Nicolson & Fawcett, 2008), the cut-off criteria of this protocol were only based on technical reading and spelling skills, phonological skills, and rapid naming skills. The number of dyslexic children in the sample is relatively high, because the school specializes in dyslexia care in the curriculum. The school pays the full assessment of all children at risk for dyslexia, which is exceptional in Dutch education. Parents often choose this school because of the opportunity of specialized dyslexia treatment inside the school.

Measures

The Dutch version of the DST-NL was administered in a quiet room by two remedial teachers and a school psychologist. The test has 14 subtests (standardized scores from 1 to 19); the risk indicator (called PLQ, Psycho Linguistic Quotient) is based on only seven subtests: Rapid Naming Pictures, Rapid Naming Letters, One-Minute Reading, Two-Minutes Spelling, Nonsense Passage Reading, Non-Word Reading, and One-Minute Writing. The other subtests are an indication of memory functioning and phonological awareness (Phonemic Segmentation 1 and 2, and Backward Digit Span) and Association (Verbal Fluency and Semantic Fluency). Although these subtests are not part of the risk indicator of the DST-NL, phonological awareness still provides a good indicator of dyslexia (Blomert, 2006; NRD, 2013). The subtests Postural Stability and Bead Threading (Physical Ability) were not administered because Kort et al. (2005) reported no significant relationship in their Dutch norm group between Physical Ability and dyslexia ($r = -.11$). The correlations (absolute value) between Postural Stability and Bead Threading and the other subtests were all < .20 in the Dutch norm group (Kort et al., 2005). Finally, the subtest Postural Stability could also be experienced as unpleasant because children are blindfolded and get a push in the back.

No differences were found in mean scores between boys and girls in our population, with one exception: boys scored significantly lower on One-Minute Writing (9.71) than girls (10.32); this finding is difficult to interpret as an ANOVA design with the relevant control variables (dyslexia diagnosis and cultural group) has a small sample size at cell level, which precludes an adequate analysis of the gender difference. The Word Lexicon school test (Cito LOVS Word Lexicon), Reading school test (Cito LOVS DMT), and the spelling school test (Cito LOVS Spelling) were administered in January in each grade. The level of Word Lexicon, Spelling, and Reading were divided in line with the test norms in five classification groups, based on the standardized scores across grades, ranging from very low (score 1) to very high (score 5). An overview of mean scores on DST-NL and school tests of the Dutch and immigrant, non-dyslexic and dyslexic children in the third, fifth, and seventh grade is shown in Table 4.2a and Table 4.2b (pp. 102 and 103).

There were differences in the language usage at home in the immigrant group, all children were asked which language they speak at home and how often; 27% of the immigrant children used only the mother tongue at home (scored as level 1), 33% used more mother tongue than the Dutch language (level 2), 17% used half mother tongue and half Dutch (level 3), 18% spoke more Dutch than the mother tongue at home (level 4) and 4% of the immigrant children used only the Dutch language at home (level 5). The predominance of Dutch spoken at home correlated significantly with the level of Word Lexicon school test score: $r = .30$, $p < .001$. Both parents of the Dutch monolingual children had Dutch as their first language.

Most immigrant participants did not have good Dutch vocabulary knowledge. The level of Dutch vocabulary knowledge (assessed with the same school vocabulary tests (see Table 4.2b for the standardized mean scores). Word Lexicon scores were significantly higher for the majority group with a large effect (effect size r: small effect size $r = .15$; medium effect $r = 30$; large effect size $r = .50$ (Cohen, 1988)) in the third (Dutch $M = 3.97$, $SD = 1.00$, immigrant $M = 2.08$, $SD = 1.19$, $t(299) = 14.97$, $p < .001$, $d = 1.73$, $r = .65$), fifth (Dutch $M = 3.74$, $SD = 1.09$, immigrant $M = 2.12$, $SD = 1.15$, $t(285) = 12.134$, $p < .001$, $d = 1.44$, $r = .58$), and seventh grade

Table 4.2a *Standardized mean scores(scaled 1-19) and standard deviations of Dutch and immigrant non-dyslexic and dyslexic third, fifth and seventh graders*

	3rd graders				5th graders				7th graders			
	Dutch		immigrant		Dutch		immigrant		Dutch		immigrant	
DST Subtest	Non-Dyslexic (*n* = 34) *M* (*SD*)	Dyslexic (*n* = 9) *M* (*SD*)	Non-Dyslexic (*n* =75) *M* (*SD*)	Dyslexic (*n* = 10) *M* (*SD*)	Non-Dyslexic (*n* = 76) *M* (*SD*)	Dyslexic (*n* = 21) *M* (*SD*)	Non-Dyslexic (*n* = 128) *M* (*SD*)	Dyslexic (*n* = 19) *M* (*SD*)	Non-Dyslexic (*n* = 74) *M* (*SD*)	Dyslexic (*n* = 24) *M* (*SD*)	Non-Dyslexic (*n* = 89) *M* (*SD*)	Dyslexic (*n* = 14) *M* (*SD*)
Naming Pictures	10.24	9.33	9.44	8.30	9.99	8.95	9.68	8.05	9.39	8.92	9.63	7.79
	(3.17)	*(2.45)*	*(3.39)*	*(2.54)*	*(2.67)*	*(3.22)*	*(3.12)*	*(2.22)*	*(2.41)*	*(2.50)*	*(2.66)*	*(2.33)*
Naming Letters	11.56	9.22	11.09	9.40	11.62	9.24	9.62	7.84	11.77	10.00	10.67	7.21
	(2.60)	*(3.77)*	*(2.98)*	*(2.01)*	*(2.78)*	*(3.36)*	*(2.97)*	*(2.04)*	*(2.74)*	*(2.75)*	*(3.04)*	*(2.29)*
One-Minute Reading	9.06	4.67	8.27	4.70	10.71	5.67	9.69	5.84	11.35	6.67	10.71	6.29
	(4.24)	*(1.32)*	*(3.27)*	*(1.16)*	*(2.72)*	*(2.20)*	*(2.66)*	*(1.89)*	*(2.33)*	*(2.14)*	*(2.37)*	*(2.23)*
Phonological Segmentation 1	9.97	8.78	9.36	8.50	10.26	7.95	9.51	8.05	9.65	6.71	8.62	7.14
	(2.56)	*(1.79)*	*(2.70)*	*(2.76)*	*(2.44)*	*(2.52)*	*(2.28)*	*(2.48)*	*(2.02)*	*(2.29)*	*(1.81)*	*(2.18)*
Phonological Segmentation 2	9.85	8.78	9.11	9.00	10.45	7.48	9.30	7.11	9.36	7.58	8.67	6.86
	(1.86)	*(.67)*	*(1.56)*	*(.00)*	*(2.08)*	*(2.18)*	*(2.02)*	*(2.42)*	*(1.98)*	*(1.77)*	*(1.72)*	*(1.92)*
Two-Minutes Spelling	10.44	8.11	9.71	8.80	10.16	6.81	9.88	7.95	10.07	7.67	9.92	7.50
	(1.83)	*(2.62)*	*(2.16)*	*(1.32)*	*(2.20)*	*(2.46)*	*(2.23)*	*(2.27)*	*(2.39)*	*(1.69)*	*(1.90)*	*(2.14)*
Backward Digit Span	9.50	9.11	8.87	8.20	10.34	9.10	10.20	10.95	10.58	10.00	10.13	10.29
	(2.35)	*(3.02)*	*(2.74)*	*(3.62)*	*(2.93)*	*(2.76)*	*(2.67)*	*(2.61)*	*(2.36)*	*(2.59)*	*(2.62)*	*(2.64)*
Nonsense Passage Reading	10.03	7.89	9.85	8.40	10.62	7.14	10.73	7.21	9.55	6.00	10.42	6.79
	(2.26)	*(1.97)*	*(2.06)*	*(1.08)*	*(2.26)*	*(3.05)*	*(2.10)*	*(1.99)*	*(2.37)*	*(1.69)*	*(2.31)*	*(3.07)*
Non-Word Reading	9.44	5.67	9.00	6.60	9.37	4.67	10.02	4.95	10.50	5.50	10.92	6.21
	(2.92)	*(1.58)*	*(2.54)*	*(1.58)*	*(2.26)*	*(2.39)*	*(1.90)*	*(2.17)*	*(2.31)*	*(2.32)*	*(2.02)*	*(1.42)*
One-Minute Writing	11.00	9.00	10.37	8.80	10.14	7.05	10.05	8.00	10.55	7.87	10.33	9.07
	(2.70)	*(2.00)*	*(2.54)*	*(3.23)*	*(2.65)*	*(2.82)*	*(2.87)*	*(3.02)*	*(2.49)*	*(2.59)*	*(2.63)*	*(2.84)*
Verbal Fluency	10.94	7.89	10.37	11.30	11.26	8.90	10.25	11.37	11.12	9.96	10.87	10.71
	(2.87)	*(3.52)*	*(3.53)*	*(3.68)*	*(3.04)*	*(3.33)*	*(2.79)*	*(2.79)*	*(2.29)*	*(3.30)*	*(2.37)*	*(1.54)*
Semantic Fluency	10.74	10.33	9.03	10.00	10.82	9.57	9.16	9.26	10.27	9.50	8.64	9.29
	(2.59)	*(2.65)*	*(2.84)*	*(2.40)*	*(2.38)*	*(1.99)*	*(2.44)*	*(1.97)*	*(2.27)*	*(1.62)*	*(2.43)*	*(2.49)*
PLQ risk score	102.44	83.89	98.01	85.20	102.62	78.86	99.58	79.58	102.47	82.62	102.49	81.14
	(15.89)	*(10.66)*	*(14.61)*	*(7.80)*	*(12.78)*	*(14.44)*	*(12.98)*	*(10.88)*	*(11.83)*	*(10.36)*	*(10.39)*	*(9.38)*

Table 4.2b *Standardized mean scores (scaled 1-19) and standard deviations of Dutch and immigrant non-dyslexic and dyslexic third, fifth, and seventh graders (all assessments of all participated children during their education career)*

	3rd graders				5th graders				7th graders			
	Dutch		immigrant		Dutch		immigrant		Dutch		immigrant	
	Non-Dyslexic (*n* = *103*)	Dyslexic (*n* = 26)	Non-Dyslexic (*n* =148)	Dyslexic (*n* = 19)	Non-Dyslexic (*n* = 90)	Dyslexic (*n* = 26)	Non-Dyslexic (*n* = 141)	Dyslexic (*n* = 19)	Non-Dyslexic (*n* = 76)	Dyslexic (*n* = 24)	Non-Dyslexic (*n* = 100)	Dyslexic (*n* = 14)
School test	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Reading school test	3.96 (*1.15*)	2.69 (*1.12*)	3.79 (*1.20*)	2.21 (*.98*)	3.96 (*1.06*)	1.68 (*.85*)	3.84 (*1.01*)	1.74 (*.81*)	4.36 (*.92*)	1.96 (*1.23*)	4.29 (*.97*)	2.14 (*1.17*)
Spelling school test	4.13 (*.98*)	3.12 (*1.34*)	3.72 (*1.11*)	3.53 (*1.26*)	3.48 (*1.29*)	1.88 (*1.07*)	3.43 (*1.15*)	1.68 (*.75*)	4.01 (*.89*)	2.75 (*1.07*)	3.69 (*1.04*)	2.29 (*.83*)
Word lexicon school test	3.97 (*1.05*)	3.96 (*.82*)	2.03 (*1.20*)	2.47 (*1.07*)	3.85 (*1.02*)	3.31 (*1.26*)	2.10 (*1.16*)	2.26 (*1.10*)	3.72 (*1.12*)	3.50 (*.83*)	2.37 (*1.04*)	2.86 (*1.03*)

(Dutch *M* = 3.67, *SD* = 1.06, immigrant *M* = 2.43*, SD* = 1.05, $t(211) = 8.55$, $p < .001$, $d = 1.18$, $r = .51$). In an ANOVA with Culture (Dutch or immigrant) and grade as fixed factors and Word Lexicon as dependent variable, the effect of Grade was not significant (as expected because of the standardized scores across grades, mentioned above), the effect of Culture was significant and large ($F(5, 315) = 98.03$, $p < .001$, $\eta^2 = .24$). The interaction between Grade and Culture was significant, yet small ($F(5, 315) = 3.79$, $p < .05$, $\eta^2 = .02$), which refers in this case to a decrease per grade in the Dutch group and an increase per grade in the immigrant group (Table 4.2b), which makes the differences in mean scores smaller over the years.

The level of parental education (i.e., the educational level in the home country of the parents) is divided in three groups: low (score 1: no education or only primary school), middle (score 2: primary school and three years of low level of high school), and high (score 3: at least four years of middle or high school). In this study, 2% of the Dutch and 53% of the immigrant parents had a low educational level in their home country, 14% of the Dutch and 15% of the immigrant parents had a middle educational level in their home country, and 83% of the Dutch and 32% of the immigrant parents had a high educational level in their home country. The differences in mean scores of the level of parental education in the Dutch and immigrant group was significant, with Dutch parents having a higher level of education, $\chi^2(2, N = 324) = 106.68$, $p < .001$.

A combined longitudinal and cross-sectional design was used. Some children were assessed in one grade, some in two grades, and others in three grades, depending on their presence at the participating school. This combined design enabled the use of all data available (thereby enlarging sample size and power in our statistical tests) and to model individual growth (rather than confounding growth and cohort differences). The period between test and retest was two year or more; therefore, we expected the effect of retest (memory) not to be very strong (Neyens & Aldenkamp, 1999).

Results

Hypothesis testing

To evaluate the association of the DST-NL with the dyslexia diagnosis and test the three hypotheses, an ROC (Receiver Operating Characteristics) analysis was calculated for each subtest and the PLQ, for the Dutch and immigrant third, fifth, and seventh graders, using the standardized scores (mean scores see Table 4.2a and 4.2b). To enlarge the number of participants in the subgroups (non-dyslexic or dyslexic, Dutch or immigrant, and third, fifth, or seventh graders), the repeated measures are included. The ROC curve plots test sensitivity on the vertical axis against its false positive rate (1 - specificity rate) on the horizontal axis. The basic measures of performance of diagnostic tests are constituted by sensitivity (the true positive rate) and specificity (the true negative rate). To interpret the ROC curves, a combined measure of sensitivity and specificity is calculated: the area under the ROC curve (AUC). The AUC, with a value between 0 and 1, is interpreted as the average value of sensitivity for all possible values of specificity. The closer the AUC is to 1, the better the overall diagnostic performance of the test, a test with an AUC value of 1 is perfectly accurate. An AUC value is acceptable if $.70 \leq AUC < .80$, excellent if $.80 \leq AUC < .90$, and outstanding if $AUC \geq .90$ (Lammers, Pelzer, Hendrickx, & Eisinga, 2007). An asymptotic significance below .05 is interpreted as showing that the discrimination power of the subtest is better than guessing.

In this research, different AUC values were found for the DST-NL subtests and PLQ scores in the groups, which were compared (all Dutch and all immigrant children who were assessed in respectively the third, fifth, and seventh grade) (Table 4.3). Three subtests, Word Reading, Nonsense Passage Reading, and Non-Word Reading, had an acceptable and significant AUC value above .70 for Dutch and immigrant children in all three grades (third, fifth, and seventh). This means that only these three DST-NL subtests combine sensitivity and specificity in an adequate manner for all children in each grade (and show considerable convergence with the dyslexia protocol outcomes), which confirms hypothesis 1. The PLQ had also a significant AUC value above .70 in all three grades. The AUC value of Word Reading is excellent in the third grade (Dutch children: AUC = .81, immigrant children: AUC = .84, see Figure 4.1 and Table 4.3), in the fifth grade (Dutch children: AUC = .92, immigrant children: AUC = .89, see Figure 4.1 and Table 4.3), and in the seventh grade (Dutch children: AUC = .92, immigrant children: AUC = .92), see Figure 4.1 and Table 4.3 for all the AUC values of the DST-NL subtests and the PLQ). This finding shows that the PLQ and protocol outcomes showed important convergence.

In the third grade, only three more subtests had a significant value above .70 for Dutch children: Two-Minutes Spelling, One Minute Writing, and Verbal Fluency. For the immigrant children, one additional subtest, Naming Letters, had a significant AUC value above .70. In summary, six DST-NL subtests and the PLQ had at least an acceptable and significant AUC score in the Dutch group and four subtests and the PLQ had at least an acceptable and significant AUC value in the immigrant group in the third grade. This finding indicates a rather low agreement between the DST-NL and protocol outcomes. In the fifth grade, two subtests, Phonological Segmentation 2 and Two-Minutes Spelling, had, in addition to Word Reading, Nonsense Passage

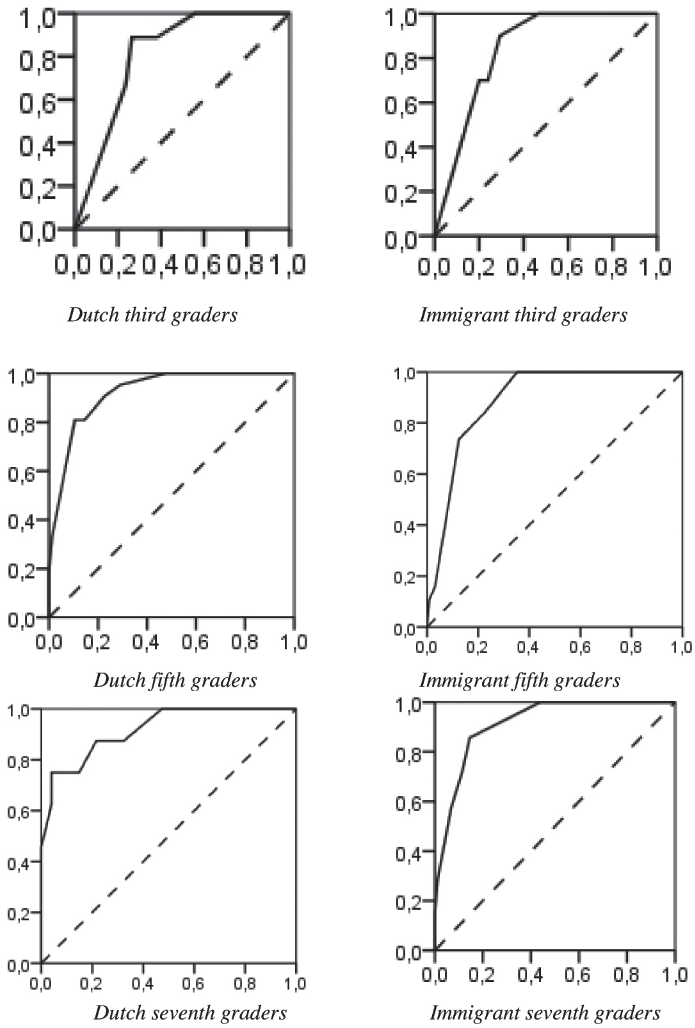

Figure 4.1 ROC curves DST subtest Word Reading for Dutch and immigrant third, fifth, and seventh graders

Reading, Non-Word Reading, and the PLQ, a significant and acceptable or excellent AUC value for both Dutch and immigrant children. Only for the Dutch children, four other subtests had significant and acceptable or excellent AUC values: Naming Letters (AUC = .71), Phonological Segmentation 1 (AUC = .76), One-Minute Writing (AUC = .80), and Verbal Fluency (AUC = .70). In the fifth grade, nine subtests and the PLQ had at least an acceptable and significant AUC score in the Dutch group, and five subtests and the PLQ had at least an acceptable and significant AUC score in the immigrant group (see Table 4.3).

In the seventh grade, besides the subtests Word Reading, Nonsense Passage Reading, Non-Word Reading, and the PLQ, three subtests had significant and acceptable or excellent AUC values in both cultural groups: Phonemic Segmentation 1 (AUC = .83 for Dutch and .71 for immigrant children), Phonemic Segmentation 2 (AUC = .74 for Dutch and .77 for immigrant children), and Two-Minutes Spelling (AUC = .79 for Dutch and .81 for immigrant children). For the Dutch children, one other subtest had a significant acceptable AUC value (One-Minute Writing) and for the immigrant children two other subtests had a significant acceptable or excellent AUC value (Naming Pictures and Naming Letters; see Table 4.3). In summary, among seventh graders, seven DST-NL subtests and the PLQ had at least an acceptable and significant AUC score in the Dutch group and eight subtests and the PLQ in the immigrant group. It seems fair to conclude that the DST and protocol outcomes agree more in higher grades and that possible cultural bias is not dealt with in the same way in the two instruments.

As can be seen in Table 4.3, the number of subtests of the DST-NL with a significant and acceptable or excellent AUC value for both majority group and immigrant children is the highest in the seventh grade (three subtests in the third, five subtests in the fifth, and six subtests in the seventh grade, respectively). More subtests had an acceptable diagnostic performance (AUC score) in the Dutch group in the third and fifth grade, whereas in the seventh grade, more subtests in the immigrant group met this AUC criterion. There were differences in diagnostic performance of the DST-NL in the third, fifth, and seventh grade; the best prediction

Table 4.3 *AUC (Area under the Curve) scores and their significance per subtest and PLQ Risk Score, all assessments (Including first-, two-, and three times tested) with the DST*

	3th grade				5th grade				7th grade			
	Dutch		Immigrant		Dutch		Immigrant		Dutch		Immigrant	
	Area	*p*	Area	*p*	Area	*p*	Area	*p*	Area	*p*	Area	*p*
Naming Pictures	.59	.42	.58	.41	.62	.10	.67	.02*	.56	.41	.70	.02*
Naming Letters	.68	.10	.72	.03*	.71	.00**	.68	.01*	.69	.01*	.82	.00***
Word reading	.81	.00**	.84	.00**	.92	.00***	.89	.00***	.92	.00***	.92	.00***
Phon. Segment. 1	.65	.18	.59	.35	.76	.00***	.66	.03*	.83	.00***	.71	.01*
Phon. Segment. 2	.65	.18	.47	.79	.81	.00***	.75	.00***	.74	.00***	.77	.00*
Two-Min. Spelling	.76	.02*	.66	.11	.85	.00***	.72	.00**	.79	.00***	.81	.00***
Backw. Digit Span	.56	.57	.55	.61	.63	.07	.43	.31	.57	.34	.48	.77
Nons. Pass. Reading	.79	.00**	.80	.00**	.83	.00***	.89	.00***	.88	.00***	.82	.00***
Non-Word reading	.88	.00**	.77	.01**	.91	.00***	.97	.00***	.93	.00***	.98	.00**
One-Minute Writing	.76	.02*	.64	.15	.80	.00***	.69	.01*	.76	.00***	.62	.16
Verbal Fluency	.73	.04*	.42	.43	.70	.01*	.38	.10	.61	.12	.53	.74
Semantic Fluency	.54	.69	.40	.30	.65	.04*	.49	.93	.60	.15	.44	.47
PLQ risk score	.84	.00**	.79	.00**	.89	.00***	.89	.00***	.89	.00***	.96	.00**

* $p < .05$, ** $p < .01$, *** $p < .001$.

Note: Italicized DST subtests are part of the PLQ risk score results were found in the fifth grade for the Dutch children and in the seventh grade for the immigrant children. The prediction value was in most cases higher for the Dutch children, which confirms hypothesis 1. The number of subtests with an acceptable or excellent prediction performance tended to become higher with grade for the immigrant group (four subtests in the third, five in the fifth, and eight in the seventh grade, respectively), as predicted in hypothesis 2. The differences in the subtests AUC values between the Dutch and immigrant children became smaller with grade for Word Reading, Phonological Segmentation 2, and Non-Word Reading, because of the increase in prediction performance in the immigrant group and the decrease in the Dutch group. Differences in the subtest AUC values became larger with grade for Naming Pictures, Naming Letters, Phonological Segmentation1, Nonsense Passage Reading, One-Minute Writing, Semantic Fluency, and the PLQ. The AUC values of Two-Minutes Writing, Backward Digit Span, and Verbal Fluency became larger between the third and fifth grade and smaller between the fifth and seventh grade. Some subtests, which are part of the PLQ risk score, were not significant for either immigrant children, or for both groups, or were significant only in a specific grade such as Naming Pictures, Naming Letters, One-Minute Writing (see Table 4.3). Verbal subtests, which are not part of the PLQ, and without an AUC value that was acceptable across all grades were Phonemic Segmentation 1 and 2, Backward Digit Span, One-Minute Writing, Verbal Fluency, and Semantic Fluency.

It can be concluded that Naming Pictures, Backward Digit Span, Verbal Fluency, and Semantic Fluency often did not yield similar results for the DST-NL and dyslexia protocol. Naming Letters, Phonemic Segmentation 1 and 2, One-Minute Writing, and Two-Minutes Spelling were somewhat more in agreement with the protocol outcomes, whereas Word Reading, Nonsense Passage Reading, and Non-Word Reading showed most agreement. Although the PLQ discriminated well between children with and without dyslexia diagnosis, we found that several, especially verbal DST-NL subtests discriminated less for immigrant children, in line with hypothesis 1 and 3. The best discriminating subtests involved technical reading aspects, which measure literacy achievement and reading and spelling achievement but probably less the underlying dyslexia source of problems in reading and spelling achievement such as phonological awareness and rapid naming.

Multilevel Modeling

Word Lexicon can be interpreted as a proxy for knowledge of the Dutch language and culture, which could be an important confounding variable to understand score differences between the mainstream and immigrant children and potential bias threats in the assessment of dyslexia, using the DST-NL. To address the role of Word Lexicon in a more detailed manner, a Hierarchical Linear Multilevel (HLM) modeling was used. This analysis (including the repeated measures) addressed individual growth, in subtest scores with grade (as independent variable, level 1) as a function of the following (level 2) predictors: Cultural Background (Dutch or immigrant), Dyslexia Diagnosis (yes or no), assessed following Blomert's (2006) and the NRD's Dutch Dyslexia Protocol (2013), Parental Education Level, and grade first DST-NL assessment. In the second analysis Word Lexicon was added as predictor. The results are presented in Table 4.4; mean scores per subtest are presented in Table 4.5. We were particularly interested in shifts in regression coefficients and their significance after introducing Word Lexicon. The latter variable was significant for each dependent variable and invariably in the expected direction. It is remarkable that introducing Word Lexicon as a predictor had no noticeable

Table 4.4 *Regression Coefficients from the HLM analysis of DST scores and all predictors without and with Word Lexicon*

	Cultural background		Dyslexia diagnosis		Parental education		Grade first assessment		Word Lexicon
	Without	With	Without	With	Without	With	Without	With	
Naming Pictures	1.77	-.33	2.20	1.79	*.83*	*1.57**	*-.99**	*-.57*	-.10***
Naming Letters	*3.39**	*.48*	5.73***	5.03**	-.98	.14	-1.42**	-1.14**	-.16***
One Minute Reading	-.91	-7.08	41.47***	42.08***	-2.54	-.04	-2.10*	-2.43*	-.37***
Phonological Segmentation 1	-.19	.16	-1.25***	-1.18***	-.01	-.15	.29***	.24***	.02***
Phonological Segmentation 2	*-.39*	*.59**	-.99**	-1.20**	*-.01*	*-.33**	2.19***	1.46***	.05***
Two-Minutes Spelling	*-.14*	*2.29****	-2.01**	-2.23**	*-.01*	*-.96***	4.44***	3.09***	.11***
Backward Digit Span	*.01*	*.35**	-.10	-.07	.12	.02	.26***	.12*	.02***
Nonsense Passage Reading	*1.65*	*4.06****	-9.24***	-8.63***	.11	-.67	1.23***	1.09**	.11***
Non-Word Reading	*-16.28*	*-39.64****	128.32***	119.03***	*3.46*	*11.29**	-17.41***	-9.57**	-1.19***
One-Minute Writing	*-.01*	*1.57***	-2.21**	-2.02**	*-.07*	*-.57**	3.01***	2.08***	.07***
Verbal Fluency	*.07*	*1.29***	-.39	-.21	.22	-.11	1.07***	.56***	.06***
Semantic Fluency	*-1.86****	*-.64*	-.70	-.41	.15	-.25	.99***	.53**	.06***
PLQ	-12.75	-47.33	171.74***	168.93***	-4.50	10.26	-5.55	-8.04	-1.88***

*$p < .05$, **$p < .01$, *** $p < .001$

Note: Cultural background means Dutch (scored as 1) or immigrant (scored as 2). Italicized numbers refer to predictors that differ in significance when lexicon is (not) included.

Table 4.5 *Raw mean scores of Dutch and immigrant non-dyslexic and dyslexic third, fifth, and seventh graders*

	3rd grade				5th grade				7th grade			
	Dutch		Immigrant		Dutch		Immigrant		Dutch		Immigrant	
Tests	Non-dyslexic	Dyslexic	Non-dyslexic	Dyslexic	Non-dyslexic	Dyslexic	Non-dyslexic	Dyslexic	Non-dyslexic	Dyslexic	Non-dyslexic	Dyslexic
Naming Pictures	*60.00*	*62.89*	*65.19*	*70.20*	*48.01*	*51.10*	*48.93*	*54.11*	*43.70*	*45.42*	*43.43*	*47.93*
Naming Letters	*51.68*	*71.56*	*56.41*	*69.40*	*32.95*	*45.14*	*41.66*	*49.21*	*25.03*	*28.83*	*27.87*	*36.29*
One-Min. Reading	*197.35*	*312.22*	*212.40*	*310.90*	*67.30*	*147.38*	*76.52*	*133.16*	*46.20*	*90.92*	*49.62*	*92.29*
Phon. Segm. 1	6.62	5.22	5.93	4.80	10.37	8.24	9.81	8.42	11.00	9.08	10.52	9.57
Phon. Segm. 2	0.76	0.00	0.31	0.00	7.09	2.67	5.25	2.42	8.41	5.79	7.69	4.50
Two-Min. Spelling	4.65	2.67	3.97	2.90	16.30	10.33	15.76	12.26	24.27	20.29	24.20	19.93
Backw. Digit Span	3.35	3.22	3.08	2.80	4.36	3.86	4.27	4.58	4.95	4.71	4.76	4.86
Nons. Pass. Reading	32.88	19.44	32.49	20.80	58.34	47.05	58.73	48.53	64.28	54.33	66.36	56.00
Non-Word Reading	*272.56*	*414.22*	*285.55*	*385.30*	*220.32*	*389.05*	*197.75*	*377.84*	*152.55*	*294.75*	*141.71*	*266.79*
One-Min. Writing	6.32	4.11	5.65	4.50	14.11	9.38	14.34	11.11	17.95	13.79	17.58	15.57
Verbal Fluency	6.03	3.44	5.53	6.40	10.01	7.14	8.70	10.00	12.15	10.71	11.75	11.43
Semantic Fluency	11.97	11.33	9.80	10.90	16.32	14.24	13.74	13.84	18.53	17.25	15.85	16.79
PLQ risk score	69.00	53.56	67.68	54.80	72.51	49.29	69.45	49.89	72.31	52.46	72.46	50.43

Note: The four Italicized subtests are speed measures where lower scores point to better performance and lower dyslexia risk.

influence on the pattern of significance of the dyslexia diagnosis, parental education, and first grade of assessment, but had a major impact on cultural background. Naming Letters and Semantic Fluency lost their significance after introducing Word Lexicon, but the opposite pattern was more common: Phonological Segmentation 2, Two-Minutes Spelling, Backward Digit Span, Nonsense Passage Reading, One-Minute Writing, and Verbal Fluency became significant. The analysis suggests that if the influence of lexical knowledge is “taken away” by introducing Word Lexicon, two semantic subtests lose their significance, Naming Letters and Semantic Fluency but most subtests start to become more strongly associated (namely Phonological Segmentation 2, Two-Minutes Spelling, Backward Digit Span, Nonsense Passage Reading, One-Minute Writing, and Verbal Fluency). Cultural and semantic knowledge had an important association with these subtests, in this research, which makes these subtests less suitable for assessment in our multicultural group as lexical knowledge seems to confound their scores.

In summary, in both analyses (ROC and HLM), we concluded that having a dyslexia diagnosis according to the dyslexia protocol is well predicted by several subtests and the PLQ, with and without controlling for Word Lexicon: Naming Letters, One-Minute Reading, Phonological Segmentation 1 and 2, Two-Minutes Spelling, Nonsense Passage Reading, Non-Word Reading, and One-Minute Writing. These subtests are not or less associated with Cultural Background or Word Lexicon achievement in the HLM analysis. More specifically, Phonological Segmentation 1 and 2 had an acceptable predictive ability in the fifth and seventh grade in the ROC analyses but not in the third grade. These subtests were less effective in the third grade. The subtests Naming Pictures, Backward Digit Span, Verbal Fluency, and Semantic Fluency could not be predicted by a diagnosis of dyslexia irrespective of grade, Cultural Background, or Word Lexicon achievement.

Discussion

The purpose of this research was to detect associations between having a dyslexia diagnosis, as assessed by the Dutch dyslexia protocol, and DST-NL (sub)test scores in the third, fifth, and seventh grade in a multicultural Dutch population and to detect possible cultural bias. Neither the DST-NL nor the dyslexia protocol outcome can be taken to constitute a gold standard against which the other instrument can be validated. Assessing dyslexia in a group of immigrants creates a serious problem due to presence of cultural bias and the confounding of language knowledge and dyslexia problems. There is no easy way to resolve this conundrum. Still, despite these problems, our study suggests various ways forward.

Different cultural and language factors can have an influence on test scores, screening for dyslexia could be more difficult in immigrant children because of these differences (Gollan & Brown, 2006; Gollan et al., 2002; Verpalen & van de Vijver, 2011, 2015). We found associations between the protocol outcome and some DST-NL subtest scores (hypothesis 1). The DST-NL was less useful in the third grade for our Dutch and immigrant participants, which made it difficult to detect dyslexia early in arguably the most important period in the reading development of the child using the DST-NL, which limits the opportunity for early intervention. Subtest scores were most accurate in the fifth grade and least accurate in the third grade, contrary to our expectation (hypothesis 2). Probably, dyslexia is easier to identify in the fifth or higher grade of our population, because differences between differences in reading skills between dyslexic and non-dyslexic children become more pronounced with age and grade. Various verbal subtests (Naming Pictures, Backward Digit Span, Verbal and Semantic Fluency) do not seem to be useful to detect a dyslexia risk in Dutch and even more so in immigrant children (hypothesis 3).

Several subtests of the DST-NL showed score differences between Dutch and immigrant children subtest scores present in our population that challenged the cross-cultural suitability of the PLQ. The subtests of the PLQ are more based on technical aspects of reading and spelling (achievement in reading and spelling) and less on the underlying cause of problems in reading and spelling (rapid naming is included but phonological awareness is no part of the risk score). The DST-NL seems useful to detect literacy problems (which are always present in dyslexic children), but may be less successful in detecting the dyslexia risk as underlying cause in our multicultural population. Probably, the composition of the DST-NL with the technical literacy tasks within the PLQ and the phonological tasks without the PLQ is not obvious because of the important role of phonological awareness in detecting dyslexia. The Dutch protocol (NRD, 2013) includes cut-off criteria for diagnosing dyslexia in three domains: phonological awareness tasks, the grapheme-phoneme association tasks, and rapid naming tasks. The DST-NL risk indicator (PLQ) has only two naming tasks relevant for these criteria included (Naming Pictures and Naming letters), from which only Naming Letters seemed to converge more with protocol outcomes.

The level of Word Lexicon, as a proxy for knowledge of the Dutch language and culture, had an association with all subtests and the PLQ, whereas the level of Parental Education was associated with only a few subtests. Differences in scores could be explained because of these associations, the immigrant group in our research had significantly lower scores on Word Lexicon and Parental Education, compared to the Dutch group in this research, in all grades (3rd, 5th, and 7th). Although research has shown that the experience of speaking two languages (with two lexical systems) may have positive implications for cognitive ability, enhancing executive-control functions across the lifespan, negative consequences of bilingualism have also been found specifically for verbal knowledge and some specific skills, such as smaller vocabularies and less rapid access to lexical items (Bialystok & Craik, 2010; Michael & Gollan, 2005). These studies found bilinguals to be slower, to commit more errors in picture naming (even in their dominant language), to obtain lower scores on verbal-fluency tasks and to demonstrate more interference in lexical decisions over the life span (Bialystok & Craik, 2010; Michael & Gollan, 2005). These negative results could be a consequence of the process of inhibition: the bilingual child does not only have to perform the task (e.g., to name the picture) but also have to select a language in which to name the picture, and to repress the other language (Green, 1998). Another possible explanation could be that the links in the lexical system between concepts and lexical representations specific to each language are weaker as a consequence of using two languages in everyday life. Bilinguals have to learn and use twice as many items as monolinguals, and they use these words less often than monolinguals, thus the connection within the lexical system between concepts and phonological representations are weaker (Gollan & Acenas, 2004; Gollan et al., 2002). Evidence of these bilingual 'processing costs' comes from studies on response time during picture naming and verbal fluency tasks, such as slower naming of pictures and reduced category and letter fluency (Gollan et al., 2002; Gollan & Silverberg, 2001). In line with these findings, we observed differences in the verbal fluency, semantic and naming tasks of the DST-NL, and we also found an association between Word Lexicon and these subtests. We found associations between some subtests and Cultural Background. Word Lexicon was associated with Cultural Background and having a dyslexia diagnosis. The influence of Word Lexicon and cultural knowledge in testing immigrant children with the DST-NL is confirmed in these findings. Our study shows a limited applicability of the DST-NL for the assessment of dyslexia risk of our population, comprising children who do not speak Dutch as their mother tongue and are not very familiar with the Dutch culture. Literacy problems are detected well with the DST-NL in this population. The tests could probably be more accurate in predicting dyslexia risk if the verbal tasks rely less on knowledge of the Dutch language or culture (for example, names of Dutch persons or pictures could be substituted by Dutch high frequency words).

A limitation of our research is the small number of immigrant children with a high level of Word Lexicon. It is another limitation of our study that we used a clinical diagnosis as the criterion to decide whether a child was dyslexic. This clinical judgement may also be susceptible to cultural bias. It is reasonable to expect that if there would be any bias in this judgement, it would go in the same direction as found in the DST-NL subtest scores. As a consequence, our estimate of cultural bias may be conservative. A criterion measure with demonstrated adequacy in a multicultural population would be a better reference point.

Research showed that it has to be possible to assess dyslexia in young children, even when they at preschool age (Elbro & Petersen, 2004; Regtvoort & Van der Leij, 2007; Van Otterloo et al., 2009; Van der Leij, 2013) and also that similar phonological and rapid naming tasks are useful to predict dyslexia in first and second language learners when they have been exposed to literacy instruction (Geva, 2000; Geva & Clifton, 1993; Geva & Siegel, 2000; Gholamain & Geva, 1999). This means that it could be possible that adaptations to the studied phonological and naming tasks, following the guidelines of the International Test Commission (ITC, 2005), could make the tasks useful for young children, regardless of their linguistic background. Further research could indicate whether it is possible to create tasks useful to assess dyslexia in a young multicultural population that could contribute to an accompanying protocol.

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Chapter 5

Dyslexia Screening in a Multicultural Context

Introduction

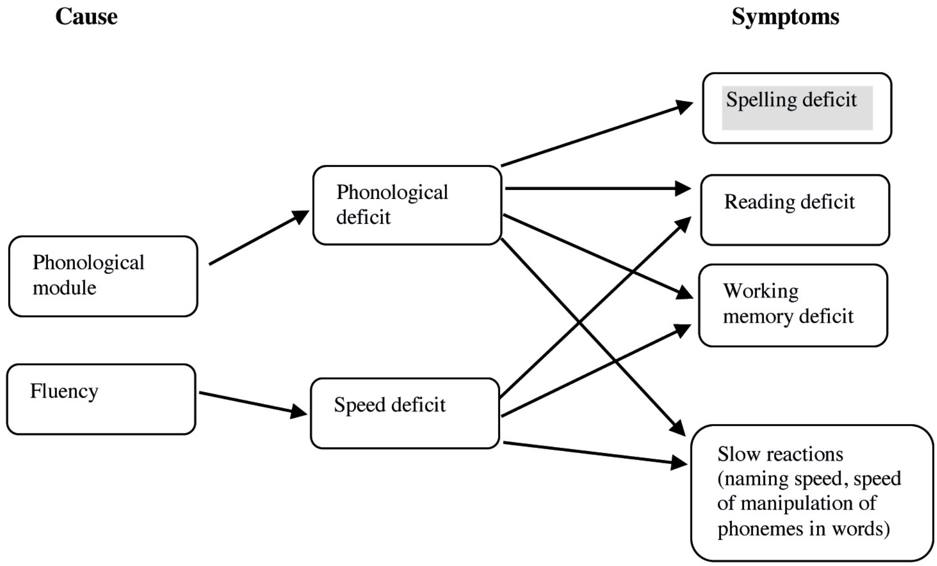
Identifying children with dyslexia seems to be very difficult with the available instruments, notably in a multicultural context. A lot of tasks, such as phonological tasks and naming tasks, rely on word lexicon and language knowledge which could lead to inaccurate testing (Cline, 2000; Peer & Reid, 2000; Verpalen & Van de Vijver, 2011, 2015). For example, the instruments used these days for dyslexia screening and assessment of Dutch children in primary schools in the Netherlands (e.g., DST-NL, 3DM Dyslexia) are mostly based on fluency and on the phonological aspects of dyslexia. The same tests are used for monolingual mainstream and bilingual immigrant children. This dual focus on fluency and phonology is guided by the double deficit hypothesis (Blomert, 2006; NRD, 2013). Missing from this protocol, however, are visual aspects of dyslexia and sensitivity to cultural differences. Following recent findings that show the complexity of dyslexia, we constructed a new dyslexia screening test, which aims to measure differences between non-dyslexic and dyslexic Dutch children of both mainstream and immigrant background, and which includes phonological, fluency-related, and visual components. The importance of including visual components was confirmed by the publishing of a new version of the dyslexia protocol in November 2016, in which visual attention span is mentioned as a skill associated with dyslexia (SDN, 2016).

In our new test items, we took cultural differences into account, by including tasks that rely less on knowledge of the testing language. This allowed us to detect differences in performance on tasks which relied on language (knowledge of letters and words) and on non-verbal versions of the same tasks, using symbols and non-words. The first purpose of this study was to further clarify the different difficulties mainstream and immigrant children exhibit, and their association with dyslexia. This would make more specific or tailored treatment possible, focused on the specific difficulties dyslexic children may face. The second purpose was to study the predictive accuracy of the various tasks in dyslexia screening for mainstream and immigrant children. When a test is used for a culturally diverse school population, it is important that it is not biased, and that it is useful for all children, regardless of differences in cultural background and home language.

Dyslexia: the double deficit hypothesis

Dyslexia is a well-known learning disorder that affects the development of reading and spelling ability. There is general agreement that it is associated with poorer phonological awareness and poorer performance on cognitive functions that are important for language processing, such as naming speed, working memory, and grapheme-phoneme mapping (Limbos & Geva, 2001; Paulesu, Démonet, Fazio, McCrory, Chanoine, Brunswick, Cappa, Cossu, Frith & Frith, 2001; Snowling, 2000; Vellutino, Fletcher, Snowling & Scanlon, 2004). One of the widely accepted theories about the phonological aspects of dyslexia at this moment is the double deficit hypothesis (see Figure 5.1), which claims that deficits in phonological awareness and rapid naming are the main problem in dyslexics (De Jong & Van der Leij, 1999; Wolf & Bowers, 1999). Neuroimaging studies of brain activity show evidence for this double deficit hypothesis with abnormalities in brain activity of the cerebral cortex during phonological and naming tasks (Blau, Van Atteveldt, Ekkebus, Goebel &

Figure 5.1 Cause and symptoms of the causal analysis of double deficit (based on Nicolson & Fawcett, 2010, grey part added (Moll, Fusseneger, Willburger & Landerl, 2009; Vaessen & Blomert, 2013)



Blomert, 2009; Shaywitz & Shaywitz, 2005; Turkeltaub, Gareau, Flowers, Zeffiro & Eden, 2003).

The test battery of the official Dutch dyslexia assessment procedure is based on this theory and the dyslexia indicators it has led to (Blomert, 2006; NRD, 2013; SDN, 2008). The procedure is advised for assessing whether or not children are dyslexic, regardless of their cultural or linguistic background. Phonological awareness is the awareness of the sound structure of oral language and the skill to manipulate the sounds of letters (phonemes) of a word (e.g., to delete a phoneme in a word) or rhyme (e.g., repetition of the same final sound in words; Quinn, Spencer & Wagner, 2016). Phonological awareness develops very similarly across languages: The awareness of syllables develops first, then the awareness of onset-rhyme units and finally the awareness of phonemes (Goswami, 2008). The most important predictor of word reading and word recognition performance is the achievement in manipulating individual phonemes, or phonemic awareness (Ehri, Nunes, Willows, Schuster, Yaghoub-Zadeh & Shanahan, 2001; Stanovich, 2000). Phonological awareness develops in stable and universal stages when a child is exposed to language. At the ages of three and four, children become aware of the syllables and phonemes in a word as well as of the whole word (Quin, Spencer & Wagner, 2016). Several factors influence the development of phonological awareness and cause individual differences: oral language exposure, the age at which words are acquired, the transparency of the language (a language is transparent if the words are pronounced as they are written, with a one letter-one sound correspondence), vocabulary knowledge, and the number of already known phonologically similar words (Cooper, Roth, Speece & Schatschneider, 2002; De Cara & Goswami, 2003; Metsala & David, 2016; Tyler & Burnham, 2006). In the preschool period, vocabulary knowledge is strongly related to phonological awareness. Growth in vocabulary knowledge has impact on the structure and (neighborhood) organization of the mental representations of spoken words. The neighborhood of words is the group of words that are phonetically similar and differ only in one letter (e.g., cork and work). Traces of words are stored in memory, based on usage, and the strength of these traces differs across individuals, and is claimed to change all the time with shifts in usage (Backus, 2015; Croft, 2000). In language learning, children are exposed to words they have not heard before. When a new word or combination is used, it may be stored in memory, and repeated usage will further entrench it (Croft, 2000). This mental lexicon (the structure of mental representations) has a direct impact on word recognition and reading achievement (Biemiller, 2003).

Research has shown that phonological awareness develops in a similar way in children with different mother tongues. In addition, it is a skill that is not restricted to the first language, as it seems to transfer to a second language (Chiappe, Siegel & Gottardo, 2002; Pang, 2009; Verhoeven, 1994). Universal cognitive and linguistic skills that can predict reading ability in both the first and the second language include phonological awareness, rapid naming, working memory, orthographic knowledge, and speed of lexical access (Durgunoğlu, Nagy & Hancin-Bhatt, 1993; Geva, 2000; Geva & Siegel, 2000). The best indicators of early reading problems and dyslexia in both the first and the second language are deficits in phonological awareness and in rapid naming (Limbos & Geva, 2001; Paulesu et al., 2001).

The second component of the double deficit theory concerns fluency. Lack of fluency in reading is one of the most important characteristics of dyslexia, which is associated with slow processing speed of all kinds of stimuli. This is indicated in such diverse tasks as naming pictures, colours, digits, and letters (Nicolson & Fawcett, 2010). Fluency is measured, for example, with a Rapid Automatized Naming task (Denckla & Rudel, 1976), which measures the ability to name objects such as colors, digits, letters, or objects quickly and accurately. Performance on the task is associated with the speed with which one gains access to representations in memory (Chiappe & Siegel, 1999; Chiappe, Siegel & Gotterdo, 2002; Lesaux & Siegel, 2003). The score on Rapid Naming is a strong indicator of early reading problems (Limbos & Geva, 2001; Paulesu et al., 2001).

Wolf and Bowers (1999) proposed the double deficit hypothesis with phonological and naming speed as the characteristic main deficits of developmental dyslexia. They distinguished three subtypes of dyslexics characterized by phonological deficits, speed deficits, or both. Phonologic awareness is associated with reading and spelling ability, rapid naming only with reading ability (Moll, Fusseneger, Willburger & Landerl, 2009; Vaessen & Blomert, 2013). In studies on second language learners, rapid naming has yielded mixed results: some studies showed slower and less accurate picture naming in immigrant children (Gollan & Brown, 2006; Roberts, Garcia, Desrochers & Hernandez, 2002; Verpalen & Van de Vijver, 2011) while others found that immigrant children did not differ in their rapid naming ability, and that immigrant children at risk for dyslexia had similar profiles as native speakers (reading disabilities with low performance in phonological and rapid naming) (Chiappe, Siegel & Gotterdo, 2002; Everatt, Smythe, Adams & Ocampo, 2000; Lesaux & Siegel, 2003; Wade-Woolley & Siegel, 1997).

Visual aspects of dyslexia

In contrast to the phonological aspects of dyslexia, the role of visual processing has received attention only in the last decades, and recent research has shown that phonological impairments are not the only problem for dyslexics. This is in line with the idea that cognitive processes are important for reading development: this would include the linguistic as well as the visual coding processes of reading (see Figure 5.2) (Vellutino et al., 2004). Reading includes four stages: attention to visual print (letters, letter-patterns, words, characters) and its identification, integration of this visual input with orthographic representations, integration of the orthographic representations with their phonological representations, and the speed of activation of the semantic and lexical information associated with those representations (Grainger & Holcomb, 2009; Singleton, 2009; Stein, 2008; Valdois, Lassus-Sangosse & Lobier, 2012; Van den Boer, Van Bergen & De Jong, 2015). The key factors involved in reading are, therefore, diverse, as is illustrated in Figure 5.2: There are auditory factors (recognizing the sounds of letters ('letter sounds'), sounds of letter

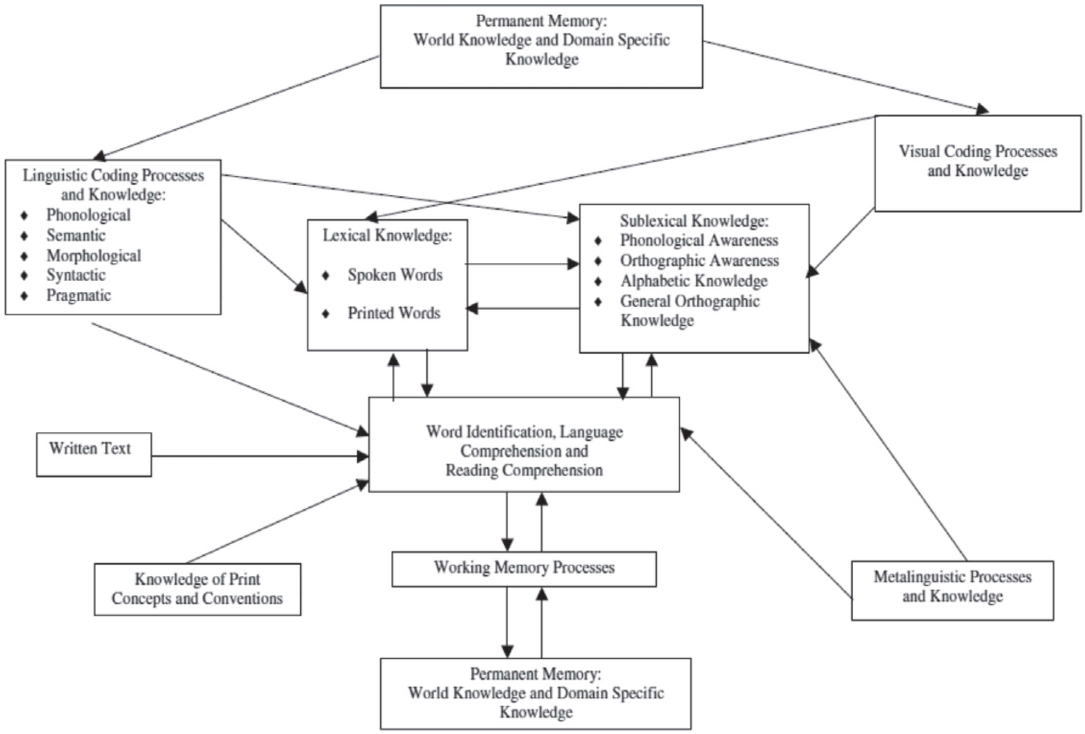


Figure 5.2 Cognitive process and types of knowledge in learning to read (Vellutino et al., 2004)

clusters or patterns, and the sequencing of letter sounds, discriminating sounds from other sounds, and recognizing individual letter sounds in words), linguistic factors (retaining the letter and word sounds in memory, articulating sounds, recognizing the sounds in written form), visual factors (recognizing the visual form of letters and words, familiarity with left-right orientation, recognizing word patterns, recognizing letter and word shapes), and contextual factors (acquiring vocabulary knowledge, acquiring general knowledge, using context for word recognition, comprehension and analogy skills) (Reid, 2016; Vellutino et al., 2004). Reid (2016) found that difficulties in the development of the auditory and visual skills important for reading are associated with dyslexia.

Stein (2001) reported that for a third of dyslexics the main problems are phonological problems, another third has mostly visual or orthographic problems, and the other third have both phonological and visual problems in almost equal proportions. The visual problems could be caused by an impaired development of visual magnocellular neurons in the brain of dyslexic children: Dyslexics are slower and less accurate in identifying individual letters and sequences of letters in words and letter clusters because of unstable focusing of attention and fixation of the eyes (Nicolson & Fawcett, 2010; Singleton, 2009; Stein, 2008, 2012). Increasing evidence for the importance of this visual attention span was shown in a brain study with young preschool children with familiar risk of dyslexia. These children, who had developed poor reading performance at the age of eight, had shown a biomarker of dyslexia in the visual domain at the age of five, before they started learning to read (Regtvoort, Van Leeuwen, Stoel & Van der Leij, 2006). These findings are in line with the outcome of studies of the influence of the visual attention span on the reading performance of dyslexic children (Bosse, Tainturier & Valdois, 2007; Bosse & Valdois, 2009).

In the first few months after birth, visual attention and perception develop and they play a role in the development of cognitive abilities and language (Schonberg, Sandhofer, Tsang & Johnson, 2014). The environment of children, regardless of their first language, could influence the development of visual attention. A young child learns to focus and ignore distractions by playing and manipulating toys. They demonstrate attention to objects in their environment. Exposure to linguistic materials (e.g., books, board games, games with letters and symbols) also influences visual perception and visual attention (Schonberg et al., 2014). Low socioeconomic status and poverty could influence this environment and as a consequence also the development of visual attention (Clearfield & Jedd, 2012; Ruff, 1986; Ruff & Capozzoli, 2003). Schonberg et al. (2014) found no differences between monolingual and bilingual preschool children in their development of visual attention and perception.

The visual component of the reading system (i.e., the processes of visual perception, eye movements, and visual attention) plays a crucial role in reading development and skilled reading (Rayner, Abbott & Plummer, 2016; Valdois, Lassus-Sangosse & Lobier, 2012). Reading relies on the visual analysis of letters, their order, and the translation of those letters into sounds (Stein, 2012). Links between the visual form of a letter or symbol (e.g., character), letter cluster, or word, and its spoken sound (phonology) have to be stored as an orthographic representation and this process depends on orthographic learning (Goswami, 2010). During reading, children perceive visual information about the text during eye fixations (the period that the eye is relatively still, 90% of the reading time). The eye moves rapidly to a new part of the text between fixations (called saccades, 10% of the reading time) (Kapoula, 2012; Rayner, Abbott & Plummer, 2016). The eyes of skilled readers move seven to nine letter spaces during a saccade, but not necessarily from word to word. On average, 25-33% of the words are skipped (mostly short and more predictable words), and in 10-15% of the saccades the eyes move backwards in the text (regressions). Eye movements differ between individuals: readers can read faster by making fewer fixations and regressions or shorter fixations, or both (Rayner, Abbott & Plummer; 2016). The perceptual span in normal readers of alphabetic writing systems is asymmetric, being larger in the direction of reading: in a script with a reading direction from left to right, the span of fixation extends from three or four letter spaces to the left to 14-15 letter spaces to the right (Rayner, Well & Pollatsek, 1980). Individual differences have been found in perceptual span related to reading ability (Rayner, Slattery & Bélanger, 2010; Ashby, Yang, Evans & Rayner, 2012). They found a smaller perceptual span in slower readers, but this could also be a consequence of difficulties in encoding the fixated word. Veldre and Andrews (2013) showed that readers with high lexical expertise (effective reading and accurate spelling ability, which lead to high quality lexical representations) had a larger perceptual span than readers with low lexical expertise.

Brain imaging techniques have been used to investigate which brain regions are universally involved in the development of reading and spelling ability. Pugh et al. (2001) summarized the consensus position of word identification related to the functional integrity of two consolidated left hemisphere posterior systems: a dorsal (temporoparietal) circuit and a ventral (occipitotemporal) circuit (visual word form area) (Shaywitz & Shaywitz, 2005) (see Figure 5.3; for a review, see Démonet, Taylor & Craix, 2004). Bolger, Perfetti and Schneider (2005) conducted a meta-analysis of 43 neuroimaging studies of word reading in European, Chinese, and Japanese readers. Similar brain regions are active across all the languages and writing systems. Figure 5.3, from Démonet et al. (2004), shows the diverse brain regions which can be disturbed in dyslexic children and adults, and what the related problems are in phonological and visual/orthographic skills (Papanicolaou et al., 2003; Shaywitz et al., 2002; Simos et al., 2000). In normal reading development, the dorsal circuit (associated with the analytic process of learning to integrate orthographic with phonological and lexical-semantic components of printed words, slow decoding) is predominated in the first stage (starting reader). In the later developed word form system of skilled readers, the ventral circuit (visual word form area, associated with fluency in memory-based letter, letter cluster, and word

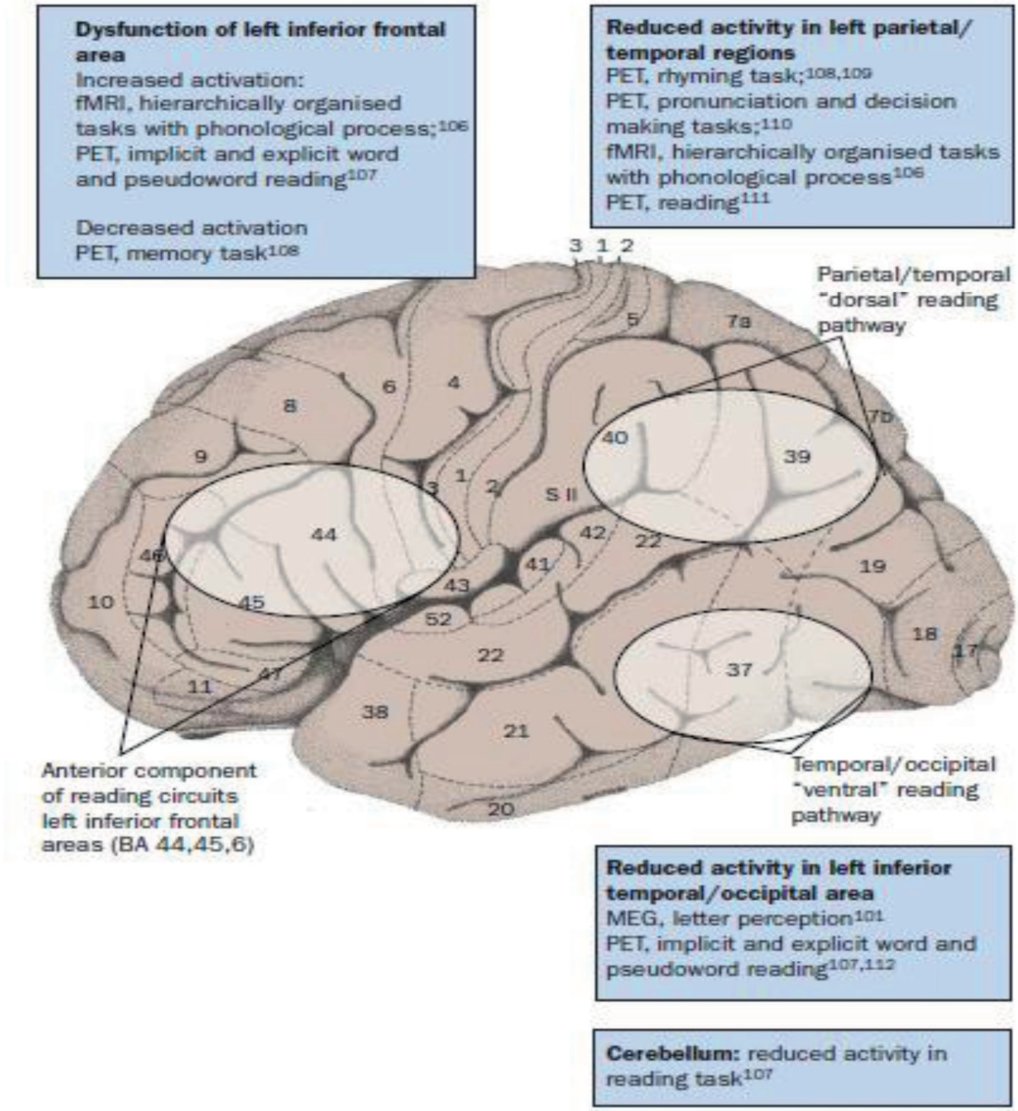


Figure 5.3 Areas of the left cerebral hemisphere in which abnormal responses in neuroimaging studies were reported in dyslexics compared with controls (From Démonet et al., 2004, p. 1455)

recognizing, responding automatically) is pre-dominated (Démonet et al., 2004; Pugh et al., 2001; Shaywitz & Shaywitz, 2005). The anterior component is centred in the left inferior frontal gyrus and connects the dorsal and ventral pathway for phonological output and articulatory aspects (Démonet et al., 2004). Dyslexics (children and adults) showed impairments in the dorsal circuit or in the ventral circuit or in both, which supports Stein's (2001) finding that there are three types of dyslexics: dyslexics with mainly phonological problems, dyslexics with mainly visual/orthographic problems, and dyslexics with both. This is also in line with what we know about the important role the linguistic coding process and the visual coding process play in reading (see Figure 5.2). (Grainger & Holcomb, 2009; Singleton, 2009; Stein, 2008; Valdois, Lassus-Sangosse & Lobier, 2012; Van den Boer, Van Bergen & De Jong, 2015; Vellutino et al., 2004).

Neuroimaging research about the neural characteristics of dyslexic bilinguals is limited, and usually done with adults, but it seems that the patterns are similar for monolinguals and bilinguals. Abutalebi (2008) reported the same activating pattern of the cortical networks for non-dyslexic bilinguals and monolinguals during linguistic and phonological tasks, but when the second language is compared with the first language, greater regions of the same active area are reported in the left hemisphere. Badzakova-Trajkov, Kirk and Waldie (2008) found that non-impaired bilingual readers who became proficient in the second language late showed activity in both hemispheres during reading to a greater extent than monolinguals. Breznitz, Revital and Shaul (2004) found slower and more effortful cerebral processing in the second language during reading compared to reading in the first language in dyslexic bilinguals, who were dominant in the first language, the localization of brain activation was similar for non-impaired readers but different for dyslexics. Oren and Breznitz (2005) reported that dyslexic readers had slower neural responses in both languages compared to monolingual dyslexics and non-dyslexic bilingual showed similar or shorter neural responses in their second language compared to their first language. You, Gaab, Cheng-Lai, Wang, Jian, Song, Meng and Ding (2010) reported similar neural deficits involved for impaired phonological processing in the second

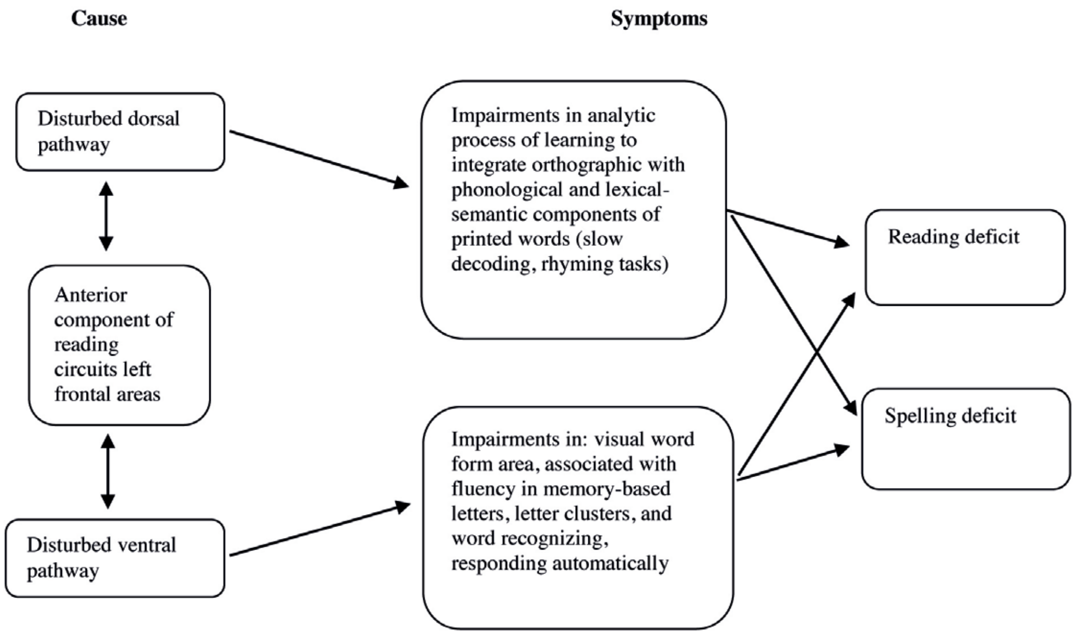


Figure 5.4 Schematic cause and symptoms of the causal analysis of developmental dyslexia based on Figure 5.3 (Démonet et al., 2004)

language (English) of reading impaired Chinese children. The recent findings on brain activity described above match with the complex reading model reported by Vellutino et al. (2004) and makes clear that a modern and cross-cultural schema of dyslexia could be presented like in Figure 5.4. This also could mean that the protocol used in the Netherlands, based on the double deficit hypothesis, with only phonological and rapid naming tasks as causal indications, is probably not up to date, because of the missing visual indicators. This idea is confirmed by the recently published new protocol of dyslexia, in which the visual attention span is mentioned for the first time in a Dutch dyslexia protocol (SDN, 2016). However, the test battery that is recommended in this protocol has not been updated yet.

Research has shown that bilingual children have weaker performance on some of these tasks, if they have a phonological character, as these require rapid word retrieval, such as picture naming (Gollan, Montoya, Fennema-Notestine & Morris, 2005; Verpalen & Van de Vijver, 2011) and verbal fluency (Gollan, Montoya & Werner, 2002; Verpalen & Van de Vijver, 2015). Screening and assessment of dyslexia seem more difficult for immigrant children because of these differences. In addition, dyslexics (mainstream as well as immigrant) who have their main problem in the visual aspect of dyslexia could easily be missed if the current protocol is used, since it is based on the double deficit hypothesis.

Present study

In this study, we tried to construct a new dyslexia screening test with tasks that tap into visual skills in addition to tasks that measure phonological skills and fluency, the battery should be useful for a multicultural school population and for fifth and seventh graders. Five hypotheses are tested. First, dyslexia is associated with six important indicators in reading and spelling development: speed of phonological skills, accurateness of phonological skills, speed of visual skills, accurateness of visual skills, technical reading and spelling skills, and memory skills. Second, phonological tasks that are less dependent on language skills (using frequent and transparent words) predict the presence of dyslexia in both mainstream and immigrant children, and both fifth and seventh graders. Third, an alternative version of these tasks that differs from the existing ones in being less dependent on language proficiency at all (by using non-words) predicts the presence of dyslexia in these same groups better than existing tests. Fourth, visual tasks that do not rely on language skills much (using, again, frequent and transparent words and letters) predict the presence of dyslexia in both mainstream and immigrant children from fifth and seventh grade. Fifth, an alternative version of these tasks that relies less on language skills at all (using non-words and symbols) predicts the presence of dyslexia in these groups. A new dyslexia screening test battery was constructed for this study, following the guidelines of the International Test Commission (ITC, 2005). If successful, this new test could form the basis for a test that can be used for Dutch populations with various cultural and linguistic backgrounds. Naturally, we tried to minimalize the effect of cultural and mother tongue differences by using only frequent words, with transparent pronunciation and meanings, school-based words that will be familiar to all pupils, and alternative test items such as non-words and symbols. The types of material used in the computer-based test items will be familiar to the intended school populations, as long as they have followed at least a few years of Dutch education. This is also a condition for learning to read and write in a second language and become testable for literacy skills.

Method

Participants

The new test was administered to 151 (74 boys, 77 girls) children in several schools, 74 children aged 8-9 years, (30 mainstream and 44 immigrant) in the fifth year of education, and 77 children aged 10-11 years (37 mainstream and 40 immigrant) in the seventh year of education. In the Netherlands, this is usually the age range during which children are assessed for dyslexia in primary school. The immigrant children were first, second, and third generation immigrants, 35% of the immigrant children were Turkish, 31% Moroccan, 12% Somalis, and 22% had other countries as cultural background, such as Afghanistan, Angola, Bulgaria, China, Iran, Iraq, and Syria. Although a few children had started their Dutch education later than the regular age of four (kindergarten), i.e., when they arrived in the Netherlands, all participants were following the regular curriculum for their grade, and had no (or no longer) lags in education at the moment of test taking. Many immigrant children speak their mother tongue at home or a mix of their mother tongue (with one or both parents) and Dutch (with their siblings).

To enlarge the number of dyslexic children in the sample, a few dyslexics were recruited from other schools which used the same school tests for reading, spelling, and word lexicon. In the total population, 26% of all children were diagnosed with dyslexia (26 boys and 13 girls), 28% of the mainstream and 24% of the immigrant children. The dyslexia assessment was conducted out of school by psychologists from different assessment centers. All these centers use the official Dutch dyslexia protocol (Blomert, 2006) and its cut-off criteria (SDN, 2008). We use this assessment as criterion although it should be acknowledged that the protocol could also be susceptible to cultural bias.

The level of education of the parents was obtained from school records. In the Netherlands, the educational level of the parents, educated in the home country, is divided in three groups: low (no education or only primary school), middle (primary school with three years up to three years of secondary education), and high (at least four years of middle or high school). This system is based on the government policies that aim to avoid lags in education by financing the approach of special needs of these children (Mens, 1984). In this study, 0% of the mainstream and 43% of the immigrant parents had a low educational level, 1.5% of the mainstream and 9.5% of the immigrant parents had a middle educational level, and 98.5% of the mainstream and 47.5% of the immigrant parents had a high level of education.

Materials

The new test battery for dyslexia screening constructed by the researcher contains many tasks. Included are six phonological tasks. The first three of these use high-frequent Dutch words (appropriate level for a beginning reader). In one task, the child has to delete a letter, in the second one, a letter has to be switched, and in the third task, the child has to reserve a word. In the other three tasks, the child has to do the same with non-words. The naming task, in which the child has to name letters, no letters are used that are more difficult for immigrant children of Turkish or Moroccan descent such as *s, c, f*, and *v* (Verpalen & Van de Vijver, 2011). The working memory task has a subtest with high frequent words and non-words. The child has to repeat the words, which are presented in an order of increasing length. The reading and spelling tasks are constructed with high frequent words. There is also an alternative reading task with non-words. Six visual tasks are added as well, in contrast to the regular assessment instruments. Three use transparent letters and words while the other three use non-words and symbols. A task to measure the automatization learning process is also added (see Table 5.1 for a description of all tasks).

The participating schools used the same school tests to measure the ability of reading, spelling, and word lexicon. These school tests are all constructed by CITO and have identical classification systems, which makes it possible to compare scores across grades. The levels of reading ability (CITO DMT), spelling (CITO LOVS Spelling), and word lexicon (CITO LOVS Word Lexicon), based on the standardized test scores across grades, were divided in five classification groups: very low (1), low (2), average (3), above average (4), and high (5). During the reading test (CITO DMT), children had to read as many words as possible in one minute. In the spelling test (CITO LOVS Spelling), children had to write the words which were

Table 5.1 *Subtests New Test Battery.*

Subtest Name:	**Description:**	**Measuring:**
Rapid Naming Letters	The child has to name correctly and rapidly as possible the name of 60 transparent (with one way of naming of pronunciation) letters.	Letter knowledge (accurateness) and rapid naming (speed of access to letter names and their pronunciation (letter sounds)
Phonological abilities	The child has to manipulate transparent words by deleting a letter in a word, switching a letter in a word and turning around a word backwards in the first component of the task. In the second part, the child has to do the same task with non-words.	Accuracy and speed of phonological awareness (e.g. word: droom -delete d (answer room), non-word: vuik- delete v (answer uik); turning words backwards: moo answer oom, non-word: kes answer sek)
One-Minute Reading	The child has to read correctly as many high frequent words as possible in one minute.	Reading performance (combination of accuracy and speed of reading)
One-Minute Non-Word Reading	The child has to read correctly as many non-words as possible in one minute.	Basic reading ability: mapping the sound to the letter
Verbal Short Term Memory	Series of spoken high frequent words and non-words are presented to the child. The child has to repeat the words and non-words.	Short term auditory memory span for words (e.g. maan – boom) and non-words (deg – klaa)
Spelling	The child has to spell as many words as possible correctly.	Spelling performance
Automatic skills	The child sees a series a symbols and after each symbol a color on the computer. The child hears the name of the color at the same time. This will be repeated four times. After this cycle, the child sees only a symbol on the computer and has to remember and combine the symbols and the matching colors.	Visual Memory skills and the learning effect of repetition
Recognize the letter	The child sees a single letter and thereafter a series letters on the computer. The child has to recognize the letter in the series and to tell if the single letter was in the series or not. In the first part of the task, the series letters are words, in the second part, the series are non-words.	Visual matching (accuracy) and visual attention (speed) (e.g. words: n – hok (answer no) and non-words: d - gdk (answer yes))
Recognize words and non-words	The child sees two words or non-words shown on the computer after each other. The child has to tell if they are the same words/non-words or not.	Visual matching (accuracy) and visual attention (speed) (e.g. words: pen – pen (answer yes) and non-words vab – vab (answer yes))
Recognize letters and symbols	The child sees two letters after each other on the computer and have to say if they are the same letter or not. The second part of the task is the same with symbols.	Visual matching (accuracy) and visual attention (speed) (e.g. b – d (answer no) and symbols ⌂ - ⌂ (answer yes)

read aloud by the teacher and in a second part, they had to choose the right spelling of a word out of four alternatives. During the word lexicon test (CITO LOVS Word Lexicon), children had to choose the correct meaning of a word out of four different descriptions of the word. This test provides a measure of the passive word lexicon.

Procedure

At all schools, the school tests (reading, spelling, and word lexicon) were administered in January by the teacher. The reading test was administered individually by the teacher in a separate room, during the lessons of an intern or colleague. The spelling and word lexicon school tests were administered in class. Finally, the researcher administered the dyslexia screening test with permission from the parents, in a separate and quiet room inside the schools, over a period of seven months.

Results

Mean differences in the standardized scores on the reading and spelling tests of the mainstream and immigrant non-dyslexic and dyslexic children were compared with a *t* test. No differences were found between the mainstream and immigrant children in their mean scores on the reading test (non-dyslexic: $t(110) = .70$, $p = .49$, dyslexic: $t(37) = -1.82$, $p = .08$) and the spelling test (non-dyslexic: $t(110) = .05$, $p = .96$, dyslexic: $t(37) = -.69$, $p = .50$). This means that the reading and spelling abilities were comparable for mainstream and immigrant children both for the dyslexic and the non-dyslexic groups. On the word lexicon test, there were mean differences in the standardized scores between the non-dyslexic and dyslexic mainstream and immigrant children, as expected: non-dyslexic: $t(110) = 7.19$, $p < .001$, dyslexic: $t(37) = 4.06$, $p < .001$ (mean scores are presented in Table 5.2).

New test items: Construct validity

To enlarge the population, the scores of the new test items are standardized in *Z* scores, to make all scores comparable across grades. The speed item scores were

Table 5.2 *Mean scores reading, spelling, and word lexicon school test*

	Mainstream *N* = 67				Immigrant *N* = 84			
	Non-dyslexic *N* = 48		Dyslexic *N* = 19		Non-dyslexic *N* = 64		Dyslexic *N* = 20	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Reading School Test	4.38	.82	2.00	.82	4.27	.82	2.55	1.05
Spelling School Test	3.92	1.07	1.89	1.10	3.91	1.15	2.10	.72
Word Lexicon School Test	3.08	.94	3.26	1.15	1.72	1.06	1.80	1.11

converted into negative direction, so that all subtests were scored in the same direction: the lower the score, the higher the risk of dyslexia. As can be seen in Table 5.3, the dyslexic and non-dyslexic children differed significantly on many of the subtests, with a large effect size (Cohen's *d*) in this multi-cultural population. A few subtests showed no mean differences between dyslexic and non-dyslexic children and are probably less associated with dyslexia: *Naming letters (accuracy), Word span (accuracy), Same letter or not? (accuracy and speed), Same symbol or not? (accuracy).* Only six subtests showed significant mean differences between mainstream and immigrant children with a medium effect size: *Switch letter of word (accuracy)*, *Turn backward non- word (accuracy)* (both rely on accurateness of phonological skills), *Word span (accuracy), Automatizing color-symbol (accuracy)* (both are associated with memory skills), and *Recognize letter in word (speed), and Recognize letter in row (speed)* (both are associated with speed of visual skills). The mainstream children performed better on these subtests (see Table 5.3).

The correlations between dyslexia and the test items can be seen in Table 5.4, for the total group and separately for the mainstream and immigrant groups. The subtests *Word span (accuracy)*, *Recognize letter in word (accuracy), Same words or not? (accuracy), Same letter or not? (accuracy and speed) and Same symbol or not? (accuracy and speed)* did not correlate with dyslexia in the total group, the

Table 5.3 *Differences in mean Z-scores between non-dyslexic and dyslexic children and mainstream and immigrant children.*

Subtest	Non-dyslexic children		Dyslexic children			Mainstream Children *N* = 67		Immigrant Children *N* = 84		
	M	*SD*	*M*	*SD*	Cohen's *d*	*M*	*SD*	*M*	*SD*	Cohen's *d*
Naming letters – accuracy	.05	.99	-.13	1.02	.18	.14	.77	-.11	1.14	.25
Naming letters – speed	.22	.87	-.63	1.07	.92***	-.12	.95	.10	1.03	-.22
Delete letter of word – accuracy	.23	.64	-.66	1.46	.96**	.16	1.03	-.13	.96	.29
Delete letter of word – speed	.32	.70	-.93	1.13	1.50***	-.02	.97	.02	1.03	-.04
Delete letter of non-word –accuracy	.24	.80	-.68	1.20	1.01***	.13	1.02	-.10	.97	.23
Delete letter of non-word – speed	.25	.76	-.73	1.23	1.09***	-.07	.94	.05	1.04	-.12
Switch letter of word – accuracy	.21	.84	-.59	1.17	.85***	.20	.92	-.16	1.03	.37*
Switch letter of word – speed	.27	.68	-.77	1.32	1.17***	-.17	1.11	.13	.88	-.30
Switch letter of non-word –accuracy	.24	.85	-.69	1.07	1.02***	.10	.96	-.08	1.03	.18
Switch letter of non-word – speed	.24	.74	-.67	1.29	1.00***	-.10	.90	.08	1.07	-.18
Turn backward word – accuracy	.23	.88	-.63	1.07	.92***	.17	1.03	-.13	.96	.30
Turn backward word – speed	.19	.69	-.54	1.45	.77**	-.09	.83	.08	1.11	-.17
Turn backward non-word –accuracy	.23	.87	-.65	1.06	.95***	.25	1.01	-.20	.95	.46**
Turn backward non-word – speed	.20	.70	-.56	1.43	.81**	-.08	.93	.06	1.05	-.14
Reading words in one minute – accuracy	.38	.80	-1.08	.65	1.91**	-.01	.99	.01	1.01	-.02
Reading non-words in one minute – accuracy	.40	.75	-1.15	.67	2.12***	-.10	.95	.08	1.03	-.18
Word span – accuracy	.03	1.01	-.08	.97	.11	.18	1.07	-.15	.92	.33*
Non-word span – accuracy	.13	1.01	-.38	.87	.52**	-.08	.93	.06	1.05	-.14
Spelling words – accuracy	.31	.89	-.88	.73	1.40***	.16	.98	-.12	1.00	.28
Automatizing color-symbol – accuracy	.13	.92	-.38	1.12	.52**	.28	.96	-.22	.98	.52*
Recognize letter in word –accuracy	.14	.58	-.40	1.65	.56*	.07	.61	-.06	1.22	.13
Recognize letter in word – speed	.20	.81	-.57	1.24	.82**	.29	.81	-.23	1.07	.54**
Recognize letter in row –accuracy	.16	.57	-.47	1.63	.66*	.15	.67	-.12	1.18	.27
Recognize letter in row-speed	.16	.81	-.47	1.30	.66***	.24	.76	-.19	1.12	.44**
Same words or not? – accuracy	.16	.47	-.45	1.73	.64*	.15	.44	-.12	1.27	.27
Same words or not? – speed	.14	.84	-.41	1.27	.57*	.13	.88	-.10	1.08	.23
Same non-word or not? –accuracy	.13	.75	-.38	1.44	.52*	.10	.74	-.08	1.16	.18
Same non-word or not? – speed	.22	.78	-.62	1.26	.91***	.02	1.03	-.01	.97	.03
Same letter or not? – accuracy	.07	.81	-.20	1.40	.27	.14	.50	-.10	1.25	.23
Same letter or not? – speed	.09	.81	-.27	1.38	.37	.13	.72	-.10	1.17	.23
Same symbol or not? – accuracy	.06	.84	-.18	1.35	.24	.14	.77	-.11	1.14	.25
Same symbol or not? – speed	.01	1.03	-.03	.90	.04	.13	.69	-.10	1.18	.23
Total score	6.01	10.36	-17.27	18.85	1.78***	2.74	14.42	-2.18	17.86	.30

**p<.05, ** p<.01, ***p<.001*

Note: Cohen's d scores are corrected by adjusting the calculation of the pooled standard deviation with weights for the sample size (Hedge & Olkin, 1985, p. 86)

mainstream group, or the immigrant group. These are the same subtests that showed no significant mean differences between the dyslexic and non-dyslexic children (Table 5.3). The pattern that can be seen in Table 5.4 is that in the mainstream group dyslexia mainly correlates with phonological subtests and in the immigrant group mainly with both phonological tasks and various visual tasks.

The structure of the test items was tested with a Factor Analysis (Extraction

Table 5.4 *Correlations test items and the dyslexia diagnose*

	Total group $N = 151$	Mainstream group $N = 67$	Immigrant group $N = 84$
		Dyslexia diagnosis	
Naming letters-accuracy	-.17*	-.18	-.18
Naming letters-speed	-.35***	-.35**	-.34**
Delete letter of word-accuracy	-.31***	-.42***	-.25*
Delete letter of word-speed	-.52***	-.61***	-.44***
Delete letter of non-word-accuracy	-.41***	-.57***	-.29**
Delete letter of non-word-speed	-.37***	-.37**	-.38***
Switch letter of word-accuracy	-.31***	-.48***	-.18
Switch letter of word-speed	-.39***	-.50***	-.30**
Switch letter of non-word-accuracy	-.37***	-.43***	-.33**
Switch letter of non-word-speed	-.35***	-.32**	-.37**
Turn backward word-accuracy	-.35***	-.52***	-.22*
Turn backward word-speed	-.25**	-.38**	-.13
Turn backward non-word-accuracy	-.38***	-.44***	-.36**
Turn backward non-word-speed	-.29***	-.37**	-.21
Reading words in one minute-accuracy	-.66***	-.73***	-.60***
Reading non-words in one minute-accuracy	-.67***	-.73***	-.63***
Word span-accuracy	-.05	-.16	-.05
Non-word span-accuracy	-.29***	-.37**	-.21
Spelling words-accuracy	-.53***	-.62***	-.46***
Automatizing color-symbol-accuracy	-.22**	-.16	-.31**
Recognize letter in word-accuracy	-.15	-.08	-.19
Recognize letter in word-speed	-.29***	-.22	-.39***
Recognize letter in row-accuracy	-.24**	-.24	-.28*
Recognize letter in row-speed	-.24**	-.20	-.30**
Same words or not? -accuracy	-.15	-.20	-.12
Same words or not? -speed	-.23**	-.17	-.31**
Same non-word or not? -accuracy	-.19*	-.10	-.27*
Same non-word or not? -speed	-.32***	-.25*	-.40***
Same letter or not? -accuracy	-.11	-.10	-.12
Same letter or not? -speed	-.10	.03	-.20
Same symbol or not? -accuracy	-.09	-.10	-.11
Same symbol or not? -speed	-.05	-.05	-.06
Total score	-.61***	-.69***	-.57***

* $p < .05$, ** $p < .01$, *** $p < .001$

Method: Principal Component Analysis, PCA, with rotation method Varimax) with a fixed number of six components (hypothesis 1). This fixed number of the components is based on the six cognitive skills of reading and spelling development that are considered important indicators of dyslexia and which were tested with the new test items: accuracy and speed of both phonological skills and visual skills, technical reading and spelling skills, and memory skills. We expected that

Table 5.5 *Factor Loadings for Principal Component Analysis with 6 fixed factors and Varimax Rotation.(largest loadings in bold)*

	Component					
Subtest	1	2	3	4	5	6
Naming letters-accuracy	.02	.12	.09	-.15	-.01	**.60**
Naming letters-speed	.43	.23	-.07	.02	**.58**	.17
Delete letter of word-accuracy	.19	.15	**.58**	.14	.17	.09
Delete letter of word-speed	**.57**	.26	.38	.08	.37	.16
Delete letter of non-word-accuracy	.15	-.04	**.75**	-.02	.21	.11
Delete letter of non-word-speed	**.53**	.25	.44	-.03	.20	.10
Switch letter of word-accuracy	.11	-.03	**.65**	.12	-.01	.08
Switch letter of word-speed	**.68**	.10	.25	.06	.21	-.02
Switch letter of non-word-accuracy	.10	.13	**.55**	.35	.22	.04
Switch letter of non-word-speed	**.65**	.27	.22	.04	.14	.17
Turn backward word-accuracy	.07	.09	.78	-.04	.07	.14
Turn backward word-speed	**.82**	.10	.09	.07	.19	.00
Turn backward non-word-accuracy	.06	.01	**.78**	.14	-.02	.21
Turn backward non-word-speed	**.88**	.06	-.03	-.15	-.10	.03
Reading words in one minute-accuracy	.33	.13	.25	.13	**.78**	.18
Reading non-words in one minute-accuracy	.32	.13	.32	.19	**.73**	.06
Word span- accuracy	-.05	.00	.12	.13	.16	**.66**
Non-word span-accuracy	-.10	-.10	.27	-.03	.09	**.64**
Spelling words-accuracy	.21	.11	.47	.18	**.56**	.13
Automatizing color-symbol-accuracy	.09	.18	.12	.28	.07	**.56**
Recognize letter in word-accuracy	.30	.18	.17	**.70**	-.03	.04
Recognize letter in word-speed	.30	**.75**	.19	.14	.00	.07
Recognize letter in row-accuracy	.30	.19	.14	**.79**	-.08	.01
Recognize letter in row-speed	.13	**.88**	.11	.11	.01	.06
Same words or not? -accuracy	.37	.06	.17	**.72**	.00	-.01
Same words or not? -speed	.29	**.75**	.01	.10	.10	.07
Same non-word or not? -accuracy	-.02	.01	.06	**.74**	.15	.12
Same non-word or not? -speed	.27	**.75**	.12	.14	.22	.02
Same letter or not? -accuracy	-.10	-.02	.00	**.77**	.11	.04
Same letter or not? -speed	.00	**.81**	-.04	.03	-.02	.10
Same symbol or not? -accuracy	-.14	.06	.05	**.75**	.14	-.05
Same symbol or not? -speed	-.10	**.66**	-.02	-.03	.19	-.06

the subtests in the PCA would show the same segmentation in components. This expectation was indeed borne out by the PCA, as can be seen in Table 5.5. The six factors explained 63% of the variance. Component 1 is associated with speed of phonological skills, component 2 with speed of visual skills, component 3 with accuracy of phonological skills, component 4 with accurateness of visual skills, component 5 with technical reading and spelling skills, and component 6 with memory skills. Contrary to our expectation, the subtest *Naming letters (accuracy)* was not associated with the visual skills but with memory skills, probably because the combination of visual input (the letter) and auditory output (say the name of the letter), relies more on memory based letter knowledge.

New test items: internal consistency

The PCA outcome showed a test structure with all six important indicators associated with reading and spelling development and with dyslexia, as expected (hypothesis 1). The reliability of these components of the test are examined with an internal consistency analysis (Cronbach's α) of the test components in each group: non-dyslexic children (mainstream and immigrant) versus dyslexic children (mainstream and immigrant) and mainstream children (non-dyslexic and dyslexic) versus immigrant children (non-dyslexic and dyslexic), and in the total group. As can be seen in Table 5.6, the reliability coefficient of component 1 (speed of phonological skills), component 2 (speed of visual skills), component 3 (accurateness of phonological skills), and component 5 (technical reading and spelling skills) was almost 0.8 or above 0.8 (high reliability, which is generally accepted for cognitive tests (Kline, 1999)) in the total group, in the non-dyslexic group, and in the dyslexic group and also in the mainstream and immigrant group. The reliability coefficient of component 4 (accurateness of visual skills) was above 0.8 for the total group, dyslexic group, and immigrant group, but not acceptable for the non-dyslexic group and mainstream group. The reliability of this component is thus not the same in each group. In the immigrant group, the reliability of this component was higher and clearly more acceptable than in the mainstream group. The reliability coefficient of component 6 (memory skills) was below 0.5, which means that this component had no acceptable reliability for all groups (total group, non-dyslexic group, and dyslexic group), probably because of the different memory function the subtests of

Table 5.6 *Internal consistency (Cronbach's α) of the six components.*

	Internal consistency Cronbach's α				
	Total group $N = 151$	Non-dyslexic children $N = 112$	Dyslexic children $N = 39$	Mainstream children $N = 67$	Immigrant children $N = 84$
Component 1	.88	.76	.89	.87	.89
Speed of phonological skills α if item deleted:					
Delete letter of word – speed	.86	.73	.87	.83	.87
Delete letter of non-word – speed	.87	.71	.90	.86	.88
Switch letter of word – speed	.86	.74	.87	.84	.88
Switch letter of non-word – speed	.87	.74	.87	.85	.88
Turn backward word – speed	.86	.73	.86	.85	.86
Turn backward non-word – speed	.86	.70	.86	.84	.86
Component 2	.89	.86	.91	.90	.88
Speed of visual skills α if item deleted:					
Recognize letter in word – speed	.86	.83	.89	.88	.85
Recognize letter in row – speed	.84	.81	.87	.88	.82
Same words or not? – speed	.86	.83	.89	.90	.84
Same non-words or not? – speed	.86	.81	.90	.88	.84
Same letter or not? – speed	.87	.83	.90	.89	.86
Same symbol or not? – speed	.90	.88	.89	.88	.90
Component 3	.83	.72	.80	.88	.75
Accurateness of phonological skills α if item deleted:					
Delete letter of word – accuracy	.81	.70	.80	.87	.72
Delete letter of non-word – accuracy	.78	.65	.76	.85	.69
Switch letter of word – accuracy	.81	.74	.76	.86	.75
Switch letter of non-word – accuracy	.81	.70	.80	.87	.72
Turn backward word – accuracy	.79	.65	.77	.84	.72
Turn backward non-word – accuracy	.78	.63	.76	.85	.69
Component 4	.86	.58	.92	.64	.89
Accurateness of visual skills α if item deleted:					
Recognize letter in word – accuracy	.84	.58	.91	.61	.86
Recognize letter in row – accuracy	.82	.49	.90	.49	.85
Same words or not? – accuracy	.84	.59	.91	.65	.86
Same non-words or not? – accuracy	.85	.49	.92	.61	.87
Same letter or not? – accuracy	.85	.52	.91	.61	.88
Same symbol or not? – accuracy	.85	.52	.91	.58	.88
Component 5	.85	.75	.72	.87	.84
Technical reading and spelling skills α if item deleted:					
Naming letters – speed	.87	.78	.64	.90	.86
Reading words in one minute – accuracy	.73	.55	.56	.77	.72
Reading non-words in one minute – accuracy	.78	.66	.67	.78	.80
Spelling words – accuracy	.84	.74	.73	.86	.82
Component 6	.36	.28	.37	.35	.35
Memory skills α if item deleted:					
Naming letters – accuracy	.28	.21	.24	.33	.24
Word-span – accuracy	.28	.19	.22	.24	.30
Non-word-span – accuracy	.43	.33	.59	.39	.39
Automatizing color-symbol – accuracy	.17	.12	.17	.15	.19

this component (word span, automatization, and letter knowledge) rely on and the unclear association between memory and dyslexia (some dyslexics have memory problems and some have not). In none of the components, Cronbach's α became clearly better if an item was deleted (see Table 5.6).

We can conclude that component 1 (speed of phonological skills), 2 (speed of visual skills), 3 (accurateness of phonological skills), and 5 (technical reading and spelling skills) had the best reliability with a value of .8 or higher. Component 4 (accurateness of visual skills) had a high reliability in the total group, the dyslexic group (mainstream and immigrant dyslexics), and the immigrant group. Component 6 (memory skills) had no acceptable reliability in any group and is not internally consistent.

Predictive validity

To calculate the predictive validity of the test items (hypothesis 2, 3, 4, 5) for the total group, mainstream group, and immigrant group an ROC (Receiver Operating Characteristics) analysis was done for each subtest and the total test score in each group (see Table 5.7). The combined measure of sensitivity (true positive rate) and specificity (the true negative rate) of each subtest and total test score gives the AUC value (Arear Under the Curve) with a value between 0 and 1. An acceptable AUC value for a subtest or test is if $.70 \leq AUC < .80$, an excellent value if $.80 \leq AUC < .90$, and outstanding if $AUC \geq .90$ (Lammers, Pelzer, Hendrickx, & Eisinga, 2007). As can be seen in Table 5.7, a lot of subtests had an acceptable or excellent AUC value in each group (total, mainstream, and immigrant group). Although almost all (sub)tests had a good predictive performance in the total group, the same pattern was found as in our previous calculations: subtests with a low predictive value

Table 5.7 *Area under the ROC curve.*

	Total group N = 151	Mainstream children N = 67	Immigrant children N = 84
	AUC	AUC	AUC
Component 1			
Speed of phonological skills			
Delete letter of word – speed	.84***	.89***	.80***
Delete letter of non-word – speed	.75***	.74**	.76***
Switch letter of word – speed	.76***	.82***	.70**
Switch letter of non-word – speed	.73***	.71**	.75**
Turn backward word – speed	.67**	.74**	.59
Turn backward non-word – speed	.69***	.74**	.64
Component 2			
Speed of visual skills			
Recognize letter in word – speed	.69***	.64	.77***
Recognize letter in row – speed	.66**	.63	.71**
Same words or not? – speed	.65**	.61	.71**
Same non-words or not? – speed	.71***	.66*	.77***
Same letter or not? – speed	.57	.48	.64
Same symbol or not? – speed	.54	.53	.54
Component 3			
Accurateness of phonological skills			
Delete letter of word – accuracy	.70***	.75**	.67*
Delete letter of non-word – accuracy	.77***	.86***	.70**
Switch letter of word – accuracy	.70***	.80***	.62
Switch letter of non-word – accuracy	.74***	.77**	.73**
Turn backward word – accuracy	.73***	.83***	.65*
Turn backward non-word – accuracy	.75***	.78***	.75**
Component 4			
Accurateness of visual skills			
Recognize letter in word – accuracy	.60	.55	.63
Recognize letter in row – accuracy	.66**	.65	.69*
Same words or not? – accuracy	.59	.62	.58
Same non-words or not? – accuracy	.62*	.56	.68*
Same letter or not? – accuracy	.57	.56	.57
Same symbol or not? – accuracy	.56	.56	.57
Component 5			
Technical reading and spelling skills			
Naming letters – speed	.73***	.73**	.73**
Reading words in one minute – accuracy	.93***	.97***	.91***
Reading non-words in one minute – accuracy	.94***	.96***	.92***
Spelling words – accuracy	.85***	.90***	.81***
Component 6			
Memory skills			
Naming letters – accuracy	.61*	.61	.61
Word-span – accuracy	.53	.60	.47
Non-word-span – accuracy	.69***	.74**	.64
Automatizing colour-symbol – accuracy	.64**	.61	.71**
Total test score	.90***	.94***	.88***

* $p < .05$, ** $p < .01$, *** $p < .001$

were mainly visual subtests, probably because children with visual problems were underrepresented (visual problems are not part of the current assessment protocol) and not recognized as dyslexic. Similarly, differences between the mainstream and immigrant children were found in the same way as in the previous analyses. More visual tasks had an acceptable predictive value in the immigrant group, which probably means that immigrant dyslexics had more difficulties with visual tasks in combination with phonological problems than their mainstream dyslexic peers. This could be a consequence of having had less exposure to literacy at home and less reading experience in the second language.

To analyze the predictive validity of the six dyslexia indicators, the scores of the subtests of each component (calculated with PCA, p. 151) were added up to yield a total score per dyslexia indicators and this was used in an ROC analysis. All indicators had a significant validity in predicting dyslexia in the total group (Table 5.8). Speed of visual skills and accurateness of visual skills had an acceptable AUC value of .7, and speed of phonological skills, accurateness of phonological skills, and technical reading and spelling skills had an excellent AUC value above .8. Although some separate memory tasks had no acceptable AUC value (Table 5.7), the total score of these subtests had an acceptable AUC value of .7 (Table 5.8). This means that the six indicators of dyslexia, measured with the subtests of this new test, were effective in assessing dyslexia and could indicate the different difficulties of the dyslexic children. The predictive validity of the six dyslexia indicators showed few differences between the mainstream and the immigrant group, the validity scores were comparable in each group and the total group. Only one indicator, accurateness of visual skills, had no significant or acceptable validity in the mainstream group, which means that these dyslexia indicators were effective predictors of dyslexia in

Table 5.8 *Area under the ROC curve per dyslexia indicator as predictor of*

	Prediction dyslexia		
	Total group	Mainstream children	Immigrant children
		AUC	
Speed of phonological skills	.82***	.86***	.78***
Speed of visual skills	.66**	.61	.71**
Accurateness of phonological skills	.82***	.89***	.78***
Accurateness of visual skills	.67**	.64	.71**
Technical reading and spelling skills	.94***	.96***	.91***
Memory skills	.68**	.71**	.66*

* $p < .05$, ** $p < .01$, *** $p < .001$

our multicultural sample and also showed the diverse patterns of difficulties in the dyslexic mainstream and immigrant child.

Discriminant analysis

A discriminant analysis was calculated to analyze the importance of each dyslexia indicator in predicting dyslexia, reading difficulties, and spelling difficulties. We first examined whether there were significant differences between the two groups (non-dyslexics versus dyslexics, children with reading difficulties versus children without reading difficulties, and children with spelling difficulties versus children with spelling difficulties). Wilks' Lambda (Table 5.9) was significant for all variables (dyslexia indicators) with highest F values for technical reading and spelling skills, accurateness of phonological skills, and speed of phonological skills, which means that there were significant group differences between non-dyslexic and dyslexic children. Almost the same pattern was found in the calculation of group differences

Table 5.9 *Test of Equality of group means between non-dyslexic and dyslexic children, children with and without reading difficulties and children with and without spelling difficulties*

	Dyslexia			Reading difficulties			Spelling difficulties		
	Wilks' Λ	*F* (1, 149)	*p*	Wilks' Λ	*F* (1, 149)	*p*	Wilks' Λ	*F* (1, 149)	*p*
Speed of phonological skills	.73	56.39	.001	.74	52.17	.001	.81	35.65	.001
Speed of visual skills	.91	14.12	.001	.98	3.15	.078	.98	3.79	.053
Accurateness phonological skills	.72	57.62	.001	.81	35.93	.001	.73	54.58	.001
Accurateness of visual skills	.93	11.48	.001	.92	13.90	.001	1.00	.73	.395
Technical reading and spelling skills	.55	121.03	.001	.58	108.47	.001	.73	.55.21	.001
Memory skills	.91	14.18	.001	.92	12.68	.001	.94	9.20	.001

between children with and without reading difficulties, only Wilks' Lambda of speed of visual skills was not significant. Less useful to indicate group differences between children with or without spelling difficulties were speed of visual skills and accurateness of visual skills, Wilks' Lambda was not significant for these variables (Table 5.9).

As can be seen in Table 5.9, technical reading and spelling skills, accurateness of phonological skills, and speed of phonological skills performed best as dyslexia indicators, but the other indicators also provide some differences between dyslexic and non-dyslexic children, children with and without reading difficulties, and between children with and without spelling difficulties. To analyze the importance of each dyslexic indicator, Table 5.10 shows the structure coefficients, the discrimination loading of each dyslexia indicator which provide the relative contribution of each dyslexia indicator to group separation in each group (dyslexic or not, reading difficulties or not, spelling difficulties or not), and their position in importance (value 1 is most important). Technical reading and spelling skills are the most important indicators to distinguish children with or without dyslexia, children with or without reading difficulties, and children with and without spelling

Table 5.10 *Standardized Discriminant Function and Structure Coefficients*

	Dyslexia			Reading difficulties (school test)			Spelling difficulties (school test)		
	Standardized Discriminant Function Coefficient	Structure Coefficient	Position	Standardized Discriminant Function Coefficient	Structure Coefficient	Position	Standardized Discriminant Function Coefficient	Structure Coefficient	Position
Speed of phonological skills	.21	.60	3	.36	.61	2	.28	.60	3
Speed of visual skills	.07	.30	5	-.32	.15	6	-.09	.20	5
Accurateness phonological skills	.43	.60	2	.21	.51	3	.64	.75	2
Accurateness of visual skills	.04	.27	6	.18	.32	4	-.33	.09	6
Technical reading and spelling skills	.76	.88	1	.83	.89	1	.62	.75	1
Memory skills	-.27	.30	4	-.24	.30	5	-.20	.31	4

difficulties, which is not surprising because of the comparable characteristics of the reading and spelling activities of the new items and the school tasks (reading task, spelling task). The positions of the other dyslexia indicators were a little different in each group, but showed the same pattern: technical reading and spelling skills, and accuracy and speed of phonological skills performed best in distinguishing group membership but memory skills and accuracy and speed of visual skills also provide some differences between these groups. The canonical correlation coefficient showed that 71.7% of the variance accounts for the differences among the dyslexic and non-dyslexic children, 69.4% among the children with and without reading difficulties, and 63.1% among the children with and without spelling difficulties. The classification results of predicting group membership with the six dyslexia indicators were very good for each group: 88.7% of original grouped cases were correctly classified as dyslexic or not, 88.1% were correctly classified as children with or without reading difficulties, and 82.8% were correctly classified as children with and without spelling difficulties.

Cultural background and the influence of word lexicon

An important purpose of our research was to construct test items that rely less on word lexicon achievement and would be useful in a multi-cultural population. The results of the analyses described above were positive, it seems that the tasks and total score of the new test do not rely much on word lexicon and nevertheless show good performance in predicting dyslexia, irrespective of cultural background. To further examine the possible influence of cultural background and (passive) word lexicon achievement, we first calculated the correlation between the subtests as well as the total score on the new test and word lexicon achievement (hypotheses 2, 3, 4, 5) (Word Lexicon School test results) per group (Table 5.11) and secondly a MAN(C)OVA. Table 5.11 showed a few, mostly weak correlations between word lexicon and some subtests in each group. In each dyslexic group (total, mainstream, and immigrant) a few subtests had a correlation with word lexicon, while in the non-dyslexic groups (total, mainstream, and immigrant) a few more subtests had a correlation with word lexicon. For the total test score, only the score of the non-dyslexic total group (i.e. non-dyslexic mainstream and immigrant children together) and the non-dyslexic immigrant group had a weak correlation with word lexicon (Table 5.11).

To analyze the differences between the mainstream and immigrant groups, a MANOVA was conducted with culture (mainstream vs. immigrant) and diagnosis (non-dyslexics vs. dyslexics) as fixed factors and the standardized (sub)test scores of the new test as dependent variables. The multivariate effect of culture was significant with a large effect size, Wilks' $\Lambda = .63$, $F(32, 116) = 2.14$, $p < .01$, (partial) $\eta^2 = .37$. The multivariate effect of dyslexia was also significant with a large effect

Table 5.11 *Correlations subtests and total score with word lexicon per group*

	Total group N = 151		Mainstream group N = 67		Immigrant group N = 84	
	Non-dyslexic children N = 112	Dyslexic children N = 39	Non-Dyslexic children N = 48	Dyslexic children N = 19	Non-dyslexic children N = 64	Dyslexic children N = 20
	Word lexicon					
Naming letters – accuracy	.19*	.31	.08	.36	.16	.29
Naming letters – speed	.07	.10	.12	.22	.18	.10
Delete letter of word – accuracy	.33***	.11	.01	.02	.26*	.23
Delete letter of word – speed	.30**	.12	.30*	.15	.32*	.27
Delete letter of non-word – accuracy	.37***	.17	.06	.03	.35**	.63**
Delete letter of non-word – speed	.22*	.30	.17	.38	.37**	.35
Switch letter of word – accuracy	.25*	.46**	-.16	.58**	.19	.57**
Switch letter of word – speed	.12	-.11	-.02	-.16	.36**	.26
Switch letter of non-word – accuracy	.10	.28	-.15	.28	.11	.30
Switch letter of non-word – speed	-.06	.20	-.09	.16	.08	.27
Turn backward word – accuracy	.23*	.15	-.24	.49*	.26*	.00
Turn backward word – speed	.07	.17	-.10	.27	.27*	.28
Turn backward non-word – accuracy	.19*	.28	-.28	.41	.15	.03
Turn backward non-word – speed	.01	.07	.02	-.09	.09	.26
Reading words in one minute – accuracy	.30**	.04	.03	.10	.47***	.09
Reading non-words in one minute – accuracy	.11	-.10	.01	-.10	.29*	-.08
Word span – accuracy	.23*	.07	.10	.27	.14	-.13
Non-word span – accuracy	.21*	.16	.15	.12	.29*	.05
Spelling words – accuracy	.29**	.48**	-.15	.66**	.38**	.39
Automatizing color-symbol – accuracy	.15	.35*	-.03	.16	.07	.39
Recognize letter in word – accuracy	.05	.15	.24	.20	-.01	.97
Recognize letter in word – speed	.32***	.24	.10	.24	.30*	-.14
Recognize letter in row – accuracy	.04	.11	-.01	.02	-.03	-.06
Recognize letter in row – speed	.20*	.01	-.06	-.08	.22	-.33
Same words or not? – accuracy	.10	.20	-.19	.37	.13	.03
Same words or not? – speed	.18	.08	.17	.13	.16	-.18
Same non-word or not? – accuracy	-.02	.14	.11	-.03	-.10	-.04
Same non-word or not? – speed	.14	.11	.07	.14	.23	.01
Same letter or not? – accuracy	-.02	.05	-.01	.46*	-.10	-.21
Same letter or not? – speed	.10	.01	.16	.08	.08	-.36
Same symbol or not? – accuracy	.04	.05	.06	-.04	-.05	-.13
Same symbol or not? – speed	.01	-.08	.04	.12	-.13	-.36
Total score	.38***	.30	.06	.40	.40**	.12

* $p < .05$, ** $p < .01$, *** $p < .001$

size, Wilks' $\Lambda = .38$, $F(32, 116) = 5.86$, $p < .001$, (partial) $\eta^2 = .62$). The effect of the interaction between culture and dyslexia was not significant, Wilks' $\Lambda = .74$, $F(32, 116) = 1.30$, $p = .16$, $\eta^2 = .26$. The univariate tests revealed that the observed effect size of culture was significant for the phonological tasks *Switch letter of word (speed), Turn backward non-word (accuracy),* the memory task *Automatizing symbol-color (accuracy),* the visual mapping and visual attention tasks *Recognize letter in word (speed), Recognize letter in row (accuracy and speed), Same word or* *not? (accuracy and speed), Same non-word or not (accuracy), Same letter or not? (speed)*, and the total score of the new test with very small effect sizes (see Table 5.12). The univariate tests showed that the observed effect size of dyslexia was significant and high for almost all subtests, the letter knowledge task *Naming letters (accuracy and speed),* the auditory short term memory task *Word Span (accuracy),* and the visual mapping task *Same letter or not? (accuracy and speed)* excepted (see Table 5.12).

To address the influence of word lexicon, a MANCOVA was conducted with culture (mainstream vs. immigrant) and dyslexia (non-dyslexic vs. dyslexic) as fixed factors and the standardized new (sub) test scores as dependent variables and word lexicon as covariate. In the MANCOVA, the multivariate effect of word lexicon (Wilks' $\Lambda = .68$, $F(32, 115) = 1.73$, $p < .05$, $\eta^2 = .33$), dyslexia (Wilks' $\Lambda = .36$, $F(32, 115) = 6.43$, $p < .001$, $\eta^2 = .64$), and culture (Wilks' $\Lambda = .66$, $F\,(32, 115) = 1.88$, $p < .01$, $\eta^2 = .34$) were significant with an effect size between small and medium (word lexicon and culture) and between medium and high (dyslexia). The interaction between culture and dyslexia was not significant (Wilks' $\Lambda = .73$, $F(32, 115) = 1.31$, $p = .15$, $\eta^2 = .27$.

After controlling for word lexicon, the effect of culture was still significant with a very small effect size on one phonological accurateness task *(Switch letter of word (speed)),* two visual matching tasks *(Recognize letter in row – accuracy, Same word or not – accuracy),* three visual attention tasks *(Recognize letter in word – speed, Recognize letter in row- speed, Same letter or not – speed)* and one memory task *(Automatizing color-symbol).* The effect of culture was no longer significant after controlling for word lexicon on a phonological accurateness task (*Turn backward non-word – accuracy) and a visual attention task (Same words or*

Table 5.12 *Multivariate analysis of variance of culture and dyslexia, before and after correcting for the effect of word lexicon as covariate*

Subtest	Culture Correction Before	 After	Dyslexia Correction Before	 After
Naming letters – accuracy	.01	.00	.01	.01
Naming letters – speed	.01	.02	.14***	.15***
Delete letter of word – accuracy	.01	.00	.17***	.17***
Delete letter of word – speed	.00	.03	.31***	.33***
Delete letter of non-word – accuracy	.00	.01	.18***	.20***
Delete letter of non-word – speed	.00	.04*	.18***	.21***
Switch letter of word – accuracy	.02	.01	.14***	.16***
Switch letter of word – speed	.04*	.05**	.22***	.22***
Switch letter of non-word – accuracy	.01	.00	.17***	.18***
Switch letter of non-word – speed	.00	.01	.16***	.16***
Turn backward word – accuracy	.01	.00	.16***	.16***
Turn backward word – speed	.01	.03*	.10***	.11***
Turn backward non-word – accuracy	.04*	.02	.17***	.17***
Turn backward non-word – speed	.00	.01	.11***	.11***
Reading words in one minute – accuracy	.00	.02	.41***	.44***
Reading non-words in one minute – accuracy	.00	.01	.47***	.47***
Word span – accuracy	.01	.00	.00	.01
Non-word span – accuracy	.01	.01	.11***	.11***
Spelling words – accuracy	.02	.00	.29***	.32***
Automatizing colour-symbol – accuracy	.08***	.05*	.06**	.06**
Recognize letter in word – accuracy	.02	.01	.06**	.06**
Recognize letter in word – speed	.11***	.05*	.13***	.14***
Recognize letter in row – accuracy	.04*	.04*	.08***	.08**
Recognize letter in row – speed	.08.**	.06**	.09***	.09***
Same words or not? – accuracy	.05*	.03	.07**	.08**
Same words or not? – speed	.03*	.01	.06**	.06**
Same non-word or not? – accuracy	.03*	.03*	.05**	.05**
Same non-word or not? – speed	.00	.00	.14***	.14***
Same letter or not? – accuracy	.02	.03*	.01	.01
Same letter or not? – speed	.04*	.03**	.03	.02
Same symbol or not? – accuracy	.03	.03	.01	.01
Same symbol or not? – speed	.01	.01	.00	.00
Total score	.05**	.00	.40***	.42***

* *p < .05,* ** *p < .01,* *** *p < .001*

not? – speed), and for the total score. The effect of culture became significant on three subtests with a very small effect size after controlling for word lexicon: two phonological speediness tasks (*Delete a letter of non-word – speed, Turn backward word – speed)* and one a visual matching task (*Same letter or not? – accuracy)*. In the MANOVA, dyslexia had a significant effect on many subtests and the total score with a high effect size, as expected. After controlling for word lexicon, the same pattern was found (see Table 5.12): dyslexia still had a significant effect on the same subtests, with a similar and mostly high effect size. It can be concluded that the new test relies less on the influence of word lexicon and discriminates well between dyslexic and non-dyslexic children in our multicultural population.

Discussion

The first purpose of this study was to examine the predictive accuracy of our newly constructed test for detecting dyslexia. We constructed an instrument that aimed to be suitable for use with both mainstream and immigrant children. In contrast to the currently used instruments, its phonological tasks rely less on language proficiency, even including alternative versions of these tasks that do minimize the use of language. The test also included new visual tasks, again in versions not relying much on linguistic proficiency. We expected that these new phonological tasks would be useful in predicting dyslexia in both mainstream and immigrant fifth and seventh graders, because the words we used had a transparent pronunciation and were highly frequent and, therefore, would not unduly disadvantage children with lower Dutch proficiency. The second purpose of the study was to examine the various difficulties dyslexic children experience and their relative importance in predicting dyslexia in mainstream and immigrant children.

We tried to construct a dyslexia screening test that is useful for a multicultural population. The key was to include tasks that do not rely as much on culture and vocabulary knowledge as the existing tests do. Our results show that it is indeed possible to detect dyslexia in a multicultural population with these new test items. Many of the individual new subtests as well as the total score proved effective in discriminating between dyslexic and non-dyslexic. The influence of cultural differences seems to be minimal. Only a few subtests proved more difficult for immigrant children, while most showed no significant mean differences. However, we also found differences between the mainstream and immigrant groups in the more detailed analyses. Immigrant children showed more difficulties with visual tasks. Most likely, this is connected to the low socioeconomic status of our immigrant sample, in which many children come from low income families and parents have a low education. Although dyslexia is not directly connected with socioeconomic status, these are risk factors for a poor literacy exposure and a small number of toys and games at home, which may influence visual attention and visual mapping skills (Ruff & Capozzoli, 2003; Schonberg et al., 2014). The role of low socioeconomic status is an interesting issue for further research.

On the phonological tasks, the differences between mainstream and immigrant children were very small, which suggests that the use of only highly frequent and transparent words and only transparent non-words was effective. The simple visual tasks (comparing letters and symbols) were probably too easy for children at this age, with a few years of literacy education, and probably only useful for starting readers. Fine-tuning the difficulty level of the tasks could be explored further, with a population of beginning readers in the third and fourth grade of primary school.

Despite our efforts to reduce the influence of vocabulary knowledge and cultural background, we still found a large multivariate effect of 'word lexicon', the test score that indicates the extent of a child's knowledge of vocabulary. The effect was restricted to a few phonological tasks with words and non-words and the technical reading and spelling tasks with existing words. In contrast, word lexicon had no influence on the scores on the visual tasks. Perhaps because the non-words we created had the same characteristics as existing words (e.g., same letter clusters), restricted lexical knowledge could lead to more difficulties in recognizing words and non-words.

Research with brain imaging technics has uncovered that there are considerable individual differences between dyslexics in what the main problems are that they experience and the relationship with differences in brain activity (Démonet et al., 2004; Shaywitz & Shaywitz, 2005; Stein, 2001). We found that our test items could be related to six important skills, all associated with dyslexia. These are the six dyslexia indicators, as developed in recent research on reading and spelling development and imaging studies of brain area activity during reading and spelling. Mainstream and immigrant children showed similar patterns in dyslexia indicators. In our study, the dyslexia indicators technical reading and spelling skills, accurateness of phonological skills, and speed of phonological skills perform best, but memory skills, accurateness of visual skills, and speed of visual skills also proved useful in discriminating between dyslexics and non-dyslexics. This means that both dyslexic children, whether of mainstream or immigrant background, might differ from one another in what they are struggling with: phonological difficulties, visual difficulties, and memory difficulties. In addition, their struggle might take different forms: difficulties in the accurateness of phonological or visual processing and difficulties with the speed of phonological or visual processing, or difficulties with both speed and accurateness. In our analyses, we found that dyslexia is associated with these six important skills, but they might all require different kinds of treatment. Our findings also showed that most of the more complex visual tasks were associated with dyslexia. This is in line with other recent research findings (Nicolson & Fawcett, 2010, Singleton, 2009; Stein, 2008, 2012). In the Dutch protocol, the recent addition of a description of visual attention and its association with dyslexia reflects these recent insights, making an update of the advised instruments necessary. When we were conducting our study, the protocol had not been revised yet, and this helps to explain the smaller number of dyslexic children with visual problems or with only visual problems, as these simply had not been assessed as dyslexic using the existing protocol.

A limitation of this research is the relatively small sample, and the small number of dyslexics within it. Also the diverse background languages of our immigrant children made our sample complex. Further research with a large scale population could further clarify the meaning of our findings and make it possible to detect the effects, if any, of different home languages with their specific characteristics.

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Chapter 6

Summary and General Discussion

Summary

In this dissertation, I examined the possibilities to detect the learning disorder dyslexia in children with a non-western cultural background. Most of the Dutch tests are developed for Dutch children and unintentionally rely on language and cultural knowledge; as a consequence, these tests could be less appropriate or more difficult for children with a non-western cultural background. This differential appropriateness is referred to as bias. The learning disorder dyslexia is associated with language; so, dyslexia screening instruments could be biased too. In this dissertation, I examined the presence of bias in a well-known dyslexia screening test: the Dyslexia Screening Test–NL (DST-NL). In Chapter 2, I compared the scores of Dutch fifth graders with the scores of their non-western immigrant classmates. The non-dyslexic non-western immigrant children scored significant lower than the non-dyslexic Dutch children, specific on the subtests 'Naming Letters', 'Verbal Fluency', and 'Semantic Fluency'. These differences are not found between the dyslexic Dutch and dyslexic non-western immigrant children. A more detailed analysis of the subtest 'Naming Letters' showed differences in naming mistakes between native Dutch, Turkish, and Moroccan children in the Netherlands. The structure of the DST-NL seemed to be equivalent for the Dutch and non-western immigrant group, but a more detailed analysis showed differences in factor loadings. Large differences between the factor loadings of the Dutch and non-western immigrant group were found for the subtests 'Naming Letters', 'Naming Pictures', and 'Verbal Fluency'.

In Chapter 2, I also examined the influence of cultural background and the level of word lexicon on DST test scores. Cultural background had a large effect on DST scores and especially on the subtests ‘Naming Letters’, ‘One minute Writing’, and ‘Verbal Influence’, with a lower score for the non-western immigrant children and on ‘Non-word reading’ with a lower score for the Dutch children. The effect size of these differences was between medium and high.

In addition, I addressed the influence of word lexicon on the cultural differences which were found. The influence of word lexicon seemed significant: after controlling for word lexicon only the subtests ‘Non-word Reading’ was still significant, with a medium effect: higher scores were found for the non-western immigrant children, which means that the observed differences were mainly caused by differences in word lexicon, in this study. I also established the influence of the level of parental education, in the same way. The influence of parental education was not significant in this study.

In Chapter 3, I compared the scores of beginning readers (third grade) with the scores of children with medium reading education and experience (fifth grade), in a multi-cultural context. I expected a faster increase in the level of word lexicon of the non-western immigrant children between the third and fifth grade. Children who are learning a second language have a language switch, mostly in the fifth grade, which means that the second language (Dutch) becomes their best and favorite language. The reading processes are different between beginning readers (mapping sounds to letters to decode a word) and readers with medium reading experience (reading with direct word recognizing), which is also found in differences in brain activity during reading. These differences can influence the performance on a dyslexia screening test. In Chapter 3, I examined the influence of these differences on DST scores in the Dutch and non-western immigrant group. The differences between the scores of dyslexic Dutch and non-western immigrant children showed no decrease, but an unexpected increase between the third and fifth grade, which confirms the universal view of dyslexia: the development of dyslexia is the same and dyslexics have the same difficulties with phonological tasks, rapid naming tasks, and phonological memory tasks regardless of their language background. In this study, detecting dyslexia was easier in the fifth grade than in the third grade, probably because of the slower development of reading and literacy skills of dyslexics. In the fifth grade, they lagged behind more than in the third grade. The effect of culture was small, only the subtests ‘Naming Letters’, ‘Backward Digit Span’, ‘Verbal Fluency’, and ‘Semantic Fluency’ showed a little influence of word lexicon and parental education.

In Chapter 4, I examine to wat extent the DST outcomes are convergent with the outcomes of the assessment with the Dutch dyslexia protocol. I examine this in a longitudinal and cross-sectional study. Dutch and non-western immigrant children of the third, fifth, and seventh grade were followed during four years.
I studied the predictive accuracy of the subtests and the total score of the DST, in predicting a dyslexia diagnosis conform the Dutch protocol, in the third, fifth, and seventh grade in a Dutch and non-western immigrant group. Only a few subtests were effective in all the three grades and were less influenced by word lexicon and cultural background: ‘One-Minute Reading’, ‘Non-Word Reading’, and ‘Nonsense-Passage-Reading’. These tasks are measured technical reading skills and showed convergence between the two assessments, DST and the protocol outcome. In the third grade, less DST subtests showed convergence with a diagnosis conform the Dutch dyslexia protocol, in both the Dutch and non-western immigrant group, but

in the fifth grade more subtests showed this convergence. In all three grades, more DST subtests were effective and showed convergence with the protocol in the Dutch groups than in the non-western immigrant groups. In this study, I also addressed the role of word lexicon and parental education. The influence of word lexicon is clear: many DST subtests are influenced by cultural background and these influences disappear after controlling for the level of word lexicon.

In the three previous studies, bias was found in various subtests of the DST, but the Dutch protocol is probably susceptible to cultural bias too. It is very difficult to avoid the influence of word lexicon and cultural background at all, but it is probably possible to decrease bias in dyslexia screening tests. In Chapter 5, I examined a new dyslexia screening test, constructed by myself, including tasks that less rely on knowledge of the Dutch language and culture. I tested the new instrument with 9- to 11-years-old Dutch and non-western immigrant children. The subtests tap into the six important dyslexia indicators, mentioned in the scientific literature: accuracy and speed of phonological awareness (phonological skills and rapid naming skills), accuracy and speed of visual tasks, auditory memory tasks, and technical reading and spelling skills. I used high frequent words from the school curriculum that are transparent in pronunciation, and non-words which are also transparent in pronunciation. I also used transparent and high frequent words, non-words, letters, and symbols in the visual tasks. The children in this study were also assessed with the Dutch dyslexia protocol. Recently (in November 2016), a new version of this protocol is published, in which, in contrary to the previous versions, an association between visual attention span and dyslexia is specified. This version was not yet published during the study described in Chapter 4. In Chapter 5, I examined the usefulness and predictive accuracy of the new test in a multicultural population. Almost all subtests and the total score of the new test were effective to distinguish dyslexic and non-dyslexic children, regardless of their cultural background. The new test was not totally free of influences of cultural background, but these influences proved to be much smaller than the DST-NL and apparent in only a few subtests. Although the dyslexic children are currently assessed with a protocol without visual tasks, the more complex visual tasks were associated with dyslexia, especially in the non-western immigrant group. This means that the addition of visual attention span in the new protocol is essential and a badly needed extension of the test battery with tasks which rely on visual attention span. Further research can clarify the role of visual skills in the assessment of dyslexia, in both mainstream Dutch and non-western immigrant children.

General Discussion

In Chapter 2 and 3, I showed that subtests of a Dyslexia Screening Test (DST-NL) are biased against non-western immigrant children. Cultural and language knowledge (vocabulary) have influences on subtest scores and make the test more difficult for these children. Differential cultural and language knowledge can lead to false positive ‘at risk for dyslexia’ indications, or to a ‘wait and see’ approach in schools when it is not clear if these children can be tested in a fair way. Chapter 4 of this dissertation showed that not every subtest of the DST showed convergence with the official assessments conform the Dutch dyslexia protocol, which could be susceptible to cultural bias too. There were also differences between the Dutch and non-western immigrant group: more DST subtests in the Dutch group were effective and showed convergence with the protocol outcome (i.e., child is dyslexic or child is non-dyslexic) than in the non-western immigrant group. In this dissertation, three important main findings emerged: firstly, it is of great importance to have a dyslexia screening instrument in education that is useful for all school pupils, regardless of their cultural and language background; secondly, the role of visual skills should be addressed in detecting dyslexia in mainstream and immigrant children, which can make specific and tailored treatment possible; and thirdly, it is important to avoid cultural and language knowledge as much as possible in tasks that address dyslexia indicators.

The relevance of detecting dyslexia at an early moment in education is clear, as it enables to start early with specific treatment and can reduce difficulties in reading and spelling development. Detecting dyslexia in non-western immigrant children seems to be more difficult, but their reading and literacy skills develop in the same way, when they follow the same education and instruction at school and even when they follow this program at a later moment after they arrived in the Netherlands. Bias in tests could lead to difficulties in detecting dyslexia in non-western children, although there is no reason to assume that these children, with adequate education, have more difficulties in learning to read and spell. This dissertation shows the importance to develop dyslexia screening and assessment test instruments which are useful for a multicultural population.

Dyslexia is a language related disorder, with universal indicators across languages. Specific language characteristics make a language more (or less) difficult to learn, such as the transparency of the language. A language with a transparent orthography, in which one letter has only one pronunciation, is easier than an opaque language, in which letters can have multiple pronunciations. Dyslexia is found in every language in which it has been studied; universal difficulties were described in Chapter 2, 3, and 4, which are difficulties in phonemic awareness and phonemic memory, difficulties in visual skills, and difficulties with reading and/or spelling. The visual skills were not mentioned in the Dutch dyslexia protocol, until November 2016, after I finished the four studies of this dissertation. The importance of visual skills in detecting dyslexia are shown in Chapter 5. Although the dyslexic children were assessed with the protocol without the visual indicators, in this study dyslexia proved to be associated with visual skills, so there is a need to add visual tasks to the current test battery and further research on these visual skills in developmental dyslexia.

The findings of the studies of this dissertation suggest that it is indeed possible to detect dyslexia in a multicultural population, with special tasks that rely less on language and culture. The construction of the new dyslexia screening test, used in the fourth study of this dissertation is a start to construct an instrument that detects dyslexia in a multicultural population. A limitation of this research project is that the tasks are tested in a small population and further research is needed to make clear the usefulness of the tasks for both, different aged Dutch and non-western immigrant children.

Chapter 7

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