Early Language and Motor Development of Dyslexic Children

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Preface and acknowledgments

From my background as a speech therapist I am interested in language disorders in children. This motivated me to search for a final research project that matched this interest to graduate the Master's programme 'Taal en spraak: verwerking en stoornissen' (Language and speech: processing and disorders) at the Utrecht University. During my search I came across a prospective longitudinal research programme which has taken place at the Utrecht Institute for Linguistics OTS since 2000. In this research programme the relation between dyslexia and developmental language disorders has been studied to clarify the presumed language disorder in children with developmental dyslexia. This research programme aims to identify linguistic precursors of dyslexia with the ultimate goal of identifying dyslexic children before they start learning to read. Early language development in children with a genetic risk for dyslexia is therefore compared to that of children with specific language impairment and typically developing age peers. Within this research programme a study was conducted that assessed sensitivity to morphosyntactic agreement in 19-month-old children at genetic risk for developing dyslexia. This study gave rise to the study that is described in this thesis.

I would like to thank all people who contributed to this project, in particular Jordie Bul for her good cooperation, enthusiasm and perseverance in preparing and conducting the study; the children as well as their parents for participating in the study; Frank Wijnen for supervising the project and for his comments on the thesis; Gerrit Bloothooft who was willing to review the thesis; Sanne van der Ven for providing her research data and sharing her experiences with the preferential listening procedure; Mathijs Bordewijk who was willing to read the whole thesis to check the English grammar and spelling; Theo Veenker who was always available to solve technical problems with the test equipment; all people who have been helpful in recruiting participants; my family and friends for their interest and support during my study.

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Introduction

Developmental dyslexia is nowadays commonly seen as a language disorder. Many studies have explored the relation between language development and dyslexia. Converging evidence suggests that the problems with literacy acquisition in dyslexia originate from deficits in the phonological module of the language system. However, there is also evidence that non-phonological aspects of language, such as semantic and syntactic skills, play an important role in the literacy development. Furthermore, motor problems and attentional deficits are frequently associated with dyslexia. This paper gives an overview of language, motor and attentional problems in dyslexics and in children at genetic risk for developing dyslexia. Attention will also be given to precursors of dyslexia and predictors of reading development.

In the first chapter a brief overview of current hypotheses concerning the underlying deficit of dyslexia will be given. The second chapter deals with the development of literacy, language and motor skills as well as attentional deficits in dyslexic children. In the third chapter precursors of dyslexia in language and motor development of children at high risk for developing dyslexia and identified predictors of reading development are discussed. The fourth chapter comprises a study of language and motor skills in toddlers at familial risk for dyslexia. Special attention will be given to two preferential listening tasks, which aimed to distinguish between two explanations of at-risk children's inability to recognize discontinuous grammatical dependencies. Next to this, measures of language development, motor skills and concentration are discussed and their influence on preference for correctly formed grammatical dependencies is analyzed.

1. Developmental dyslexia

Developmental dyslexia refers to a disturbance in the acquisition of reading and spelling skills. Sometimes the term specific reading disorder is used instead of dyslexia. It is a hereditary disorder with an incidence of 2-12% (Elbro et al., 1998; Pennington & Lefly, 2001; Scarborough, 1990). Children with at least one dyslexic parent, however, have a considerable higher risk; they have between 32 and 68% chance of developing dyslexia (Elbro et al., 1998; Pennington & Lefly, 2001; Scarborough, 1990). Several studies have found a sex bias towards males for the incidence of dyslexia; more than twice as many males than females are affected (Miles et al., 1998; Rutter & Yule, 1975; Sauver et al., 2001; Flannery et al., 2000; Shaywitz et al., 1990). However, it is not clear whether male children are biologically predisposed to developing dyslexia (Flannery et al., 2000), or are more commonly diagnosed due to referral bias (Shaywitz et al., 1990).
Controversies have led to several definitions and theories concerning the underlying cause of dyslexia. These controversies are due to heterogeneity in the behavioural profile of dyslexia: symptoms of dyslexia change with age (Snowling, 2000), co-occurring disorders lead to a change in behavioural manifestations (Snowling, 2000), and the behavioural manifestation of dyslexia differs across languages (Snowling, 2000; Vellutino, 2004).

1.1. Definitions

One of the first definitions of dyslexia was drafted by the World Federation of Neurology in 1968: *Dyslexia is* a *disorder manifested by a difficulty in learning to read despite conventional instruction, adequate intelligence and socio-cultural opportunity. It is dependent upon fundamental cognitive difficulties which are frequently of a constitutional character* (Snowling, 2000). Since this time several organizations came up with different definitions of dyslexia. The Dutch dyslexia association ‘Stichting Dyslexie Nederland’ has tried to end the controversies. Two medical classification systems were used as starting point in defining dyslexia: the International Classification of Impairments, Disabilities and Handicaps (ICIDH) of the World Health Organization (WHO, 1980) and the DSM-IV diagnostic criteria for reading disorder (APA, 1994). The association came up with the following in the Netherlands commonly accepted and used definition: *Dyslexia is an impairment characterized by a persistent problem in the acquisition and the accurate and/or fluent application of reading and/or spelling skills at word level. The reading level is significant below the expectations on the base of age and circumstances. The problems are didactically resistant* (Stichting Dyslexie Nederland, 2003).

1.2. Theories

It is widely agreed that the underlying deficit of developmental dyslexia is a core problem in the verbal domain (Vellutino, 1979; Lyytinen et al., 2004; Rispens, 2004; Vellutino et al., 2004). Vellutino (1979) was the first to propose that dyslexia is a language disorder. He pointed out that the previous findings seen as evidence for a perceptual deficit in dyslexia were entirely consistent with the view that dyslexic readers have verbal decoding deficits. Evidence for his hypothesis was found by studies pointing to delays in speech and language development. However, this verbal deficit hypothesis turned out to be too general (Snowling, 2000). Not all dyslexics fitted into the proposed model. Furthermore, findings of deficits in some but not all verbal domains were not in line with this hypothesis. Consensus on the more specific nature of the underlying deficits or delays in language development which lead to dyslexia has not yet been reached. Some current theories will be discussed here.

- The phonological deficit theory

Next to reading and writing problems the most consistently reported difficulties in dyslexics are phonological processing deficits (Gallagher et al., 2000, Snowling 2000, Vellutino et al., 2004). Several theories have been proposed which relate the reading problems to these phonological problems. The phonological deficit theory postulates that dyslexics have a specific impairment in the representation, storage, and or retrieval of speech sounds. Thus, there is a deficit in which the brain codes the phonological properties of words. The impaired representation of speech sounds results in a vague or underspecified phonological representation. Children who come to the task of learning to read with poorly specified phonological representations have difficulties in setting up mappings between orthographic and phonological sequences (Snowling, 2000; Ramus, Rosen et al., 2003; Vellutino et al., 2004).

This theory is supported by the previously mentioned findings of phonological deficits and by anatomical and functional brain imaging studies, which have found evidence for a left perisylvian dysfunction as a basis for the phonological deficit (Ramus, 2003).

However, the phonological deficit theory is imprecise, as it does not elaborate on what a vague representation exactly is. Moreover, relating reading problems to phonological processing deficits seems paradoxical, because most dyslexic children do not show difficulties with the production of speech sounds and children who have isolated problems with speech-sound production do not typically develop reading problems (Bishop & Snowling, 2004). A popular current view is that reading problems arise when phonological awareness is weak (Bishop and Snowling 2004). Next to letter-sound knowledge (Byrne, 1998, cited in Bishop & Snowling, 2004), phonological awareness has been identified as the skill critical to the translation of print to sound and sound to print in an alphabetic script (Snowling, 2000; Ramus, 2003; Vellutino et al., 2004). However, the fact that non-phonological aspects of language, such as semantic and syntactic skills (see below for references) differentiate between dyslexic and typical readers as well, suggests that dyslexia cannot be exclusively explained by phonological processing deficits. Furthermore, this theory is not able to explain sensory and motor disorders that are observed in a significant number of dyslexics (Ramus, Rosen et al., 2003).

Alternatives to the phonological deficit theory are the temporal processing theory, the cerebellar theory and the magnocellular theory, with the last two being the most prominent. The common property of these theories is that they postulate an underlying cause for the phonological processing problems in dyslexia.

- Temporal processing theory

Tallal (Tallal and Piercy, 1973; Tallal, 1980, both cited in Rosen, 2003) proposed that phonological deficits are the result of a low-level auditory perception deficit in the processing of brief or rapid sounds. This was based on the performance of dyslexics and specific language impaired children in different experiments in which they showed problems in processing brief and rapidly changing acoustic information. It was expected that the recognition of formant transitions, brief acoustic transitions that cue distinctions between consonants, would also be affected.

Several weaknesses of this theory are noted by Ramus (2003), Rosen (2003), and Bishop and Snowling (2004). These include failures to replicate the finding of auditory temporal processing deficits in dyslexia. Furthermore, not all dyslexics have problems with auditory processing and these problems are not restricted to brief or rapid stimuli. Also, perceptual difficulties are often uncorrelated with phonological problems.

- The cerebellar theory

The cerebellar theory was proposed by Nicolson and Fawcett (1990) and states that the cerebellum, which is important for motor control and automatization, is mildly dysfunctional. Motor control problems may affect speech articulation. It is assumed that the deficient phonological representations in dyslexics are caused by delayed or dysfunctional articulation. Furthermore, the difficulties in learning grapheme-phoneme correspondences are explained by a weak capacity to automatize. This theory is supported by poor performance in various motor tasks, dual task situations and non-motor cerebellar tasks, such as time estimation. Further support comes from imaging studies which have found anatomical and activation differences in the cerebellum of dyslexics (Ramus, Rosen et al., 2003). A weakness of this theory is that it is not able to explain the occurrence of sensory problems or the absence of motor problems in a significant proportion of dyslexics (Ramus, Rosen et al., 2003). Additionally, it relies on an assumption of the motor theory of speech perception, according to which the development of phonological representations relies on speech articulation (Liberman et al., 1963, cited in Ramus, Pidgeon & Frith, 2003). This assumption is outdated (Liberman & Mattingly, 1985; Ramus, Rosen et al. 2003).

- The magnocellular theory

The magnocellular theory is unique in accounting for reading problems both through auditory–phonological and visual–spatial deficits. It encompasses all known cognitive, sensory and motor manifestations of dyslexia. According to this theory the often observed visual, auditory, tactile, motor and phonological deficits in dyslexics are based on general difficulties in temporal processing, independent of the modality (auditory, visual or motor). These general difficulties in temporal processing have to be connected to the magnocellular system in the brain. A dysfunction of cells in the magnocellular pathways affects all sensory modalities and prolongs itself in the posterior parietal cortex and the cerebellum (Stein & Walsh 1997, Ramus, Rosen et al., 2003). Evidence specifically relevant to this theory comes from psychophysiological findings (Lyytinen et al., 2005; Ramus, Rosen et al., 2003), poor performance of dyslexics in the tactile domain, and the co-occurrence of visual and auditory problems in a subset of dyslexics (Ramus, Rosen et al., 2003). However, this theory fails to explain the absence of these sensory and motor disorders in other subgroups of dyslexics. Failures to replicate temporal processing deficits for both visual (Olson & Datta, 2002, cited in Savage, 2004) and auditory domains (Breznitz, 2002; Chiappe, Stringer, Siegel & Stanovich, 2002; Marshall, Snowling & Bailey, 2001; Share, Jorm, Maclean &Matthews, 2002, all cited in Savage, 2004) argue against the existence of a reliable temporal processing problem in dyslexia. Furthermore, this theory relies on the idea that the magno-/parvocellular distinction in the visual system can be extended to non-visual sensory systems, which is still controversial (Ramus, Rosen et al., 2003).

Ramus, Rosen et al. (2003) conducted a study, which aimed to decide between these theories. They tested adult dyslexics on psychometric, phonological, auditory, visual and cerebellar tests. All of them showed deficits on the phonological tasks. About 30% seemed to have a purely phonological deficit, whereas the others suffered from additional auditory, visual, or motor disorders. More than half of the sample had auditory problems, but these could not be characterized as a rapid auditory processing deficit, contrary to predictions of the temporal processing theory or the magnocellular theory. 25% of the dyslexics showed deficits on the cerebellar tests and 12.5% in the sample seemed to have visual problems of a magnocellular nature. In contrast to the predictions of the cerebellar theory, no influence of motor or cerebellar performance on phonology or literacy was found. Taken together, these results support the phonological deficit theory. Even though Ramus, Rosen et al. (2003) are cautious in referring to this deficit as the necessary cause of developmental dyslexia, they state that it is a sufficient cause, as phonological deficits can arise independently of any sensory or motor impairment. Also Vellutino (2004) and Snowling (2000) argue that the phonological deficit theory is the most plausible.

In this introductory chapter definitions of dyslexia and theories concerning the underlying cause were described. In the next chapter the behavioural manifestation of dyslexia in literacy, language and motor development is discussed.

2. Literacy, language and motor skills in dyslexic children

The most prominent problem in dyslexia is the acquisition of literacy skills. The reading problems are manifested in extreme difficulties in acquiring the basic reading subskills such as word identification and phonological (letter-sound) decoding. Furthermore spelling is affected. These deficits tend to be accompanied by specific deficits in cognitive abilities related to reading and other literacy skills (Vellutino et al., 2004).

2.1. Learning to read

The aim of reading education is skilled reading, which may be defined as the process of extracting and constructing meaning from written text for a purpose. It is a complex process that depends on adequate development of word identification and language comprehension. In order to comprehend what one reads, one must be able to identify the words contained in running text with enough accuracy and fluency to allow computation of the meanings embodied in the text within the limits of the working memory. Furthermore knowledge of the world and adequate domain specific knowledge is needed (Vellutino et al., 2004). Plaut et al. (1996) proposed a model in which reading is conceptualized as an interaction between a phonological pathway mapping between letters and sounds and a semantic pathway mapping between letters and sounds via meaning. In the early stages of learning to read children's attention is devoted to establishing the phonological pathway, whereas later they rely increasingly on word meanings (semantic pathway) to gain fluency in their reading. In the later stages of reading development Plaut et al. showed that the pathways became highly specialized; the semantic pathway dealt primarily with the reading of exception words, while the phonological pathway continued to be involved in the reading of words with consistent pronunciations (Snowling, 2000).

Learning to read in an alphabetical system is strongly related to phonological processing. Children who master the alphabetical principle are able to read letter strings they have not seen before. Dyslexic children have problems at the phonological level, which leads to the expectation that they should be at least slow, and at worst fail, to develop alphabetical decoding skills (Snowling, 2000). Because of the phonological deficit dyslexic children face the task of trying to read from a foundation that is not optimal for creating mappings between sounds and letters. This will lead them to create 'coarse-grained' mappings that are adequate for the establishment of associations between whole words and their pronunciations, but does not support the development of fine-grained links between graphemes and phonemes (Snowling 2000).

The clearest consequence of the phonological deficit is on reading and spelling development. Typically the reading of unfamiliar words will remain very difficult and prone to errors and spelling may be characterized by phonetically unacceptable errors (Snowling 2000). Variation in reading skills among dyslexic children has been observed. Some children have relatively more difficulty in reading nonwords or novel words than exception words and their spelling is characterized by phonetically unacceptable errors, whereas others have more difficulty with reading exception words than nonwords or novel words and have phonetic spelling. These reading profiles can be seen as two different subtypes, namely phonological and surface dyslexia respectively. However, Snowling argues that individual differences in reading behaviour should be viewed as the outcome of an interaction between a phonological deficit and other cognitive skills, as evidence in favour of distinct subtypes is lacking (Snowling, 2000). Dyslexic children who have more severe phonological deficit have worse decoding skills. However, the phonological deficit may be moderated by other cognitive skills, such as visual memory or semantic processing abilities.

It has also to be taken into account that reading and spelling problems associated with dyslexia differ in different languages (see Vellutino et al., 2004 and Snowling, 2000). Learning to read in alphabetic languages such as English or Dutch is different from learning to read in non-alphabetic languages such as Chinese, in which visual symbols present units of meaning rather than phonemes. Furthermore, differences in reading problems have been observed between languages with opaque and transparent orthographies.

English has an opaque orthography in which relationships between letters and sounds are inconsistent and many exceptions are permitted, whereas languages such as Dutch and Finnish have more transparent orthographies containing more consistent mappings between letters and sounds.

2.2. Language skills

- *phonology*

Difficulties of dyslexic people extend beyond the domain of written language and can be found in performance on a range of tasks that require phonological processing (Gallagher et al., 2000; Snowling, 2000; Vellutino et al., 2004). Next to limitations of verbal short-term memory, deficient phonological awareness is the most consistently reported difficulty in dyslexics (Snowling, 2000, 2005). It involves reflecting on the sound structure of words separately from their meaning, grammar or spelling (Simpson, 2000) and is tested in tasks in which syllables or phonemes have to be identified, manipulated, added or deleted in spoken language (Aarnoutse, 2004). Moreover, subtle impairments can be observed in speech perception and production, including naming deficits, deficits in rapid automized naming and verbal repetition deficits (Snowling, 2000).

It has to be noted that faster development of reading and phonological awareness has been found in languages with consistent mappings between letters and sounds (transparent orthographies) as compared to languages with inconsistent mappings between letters and sounds (opaque orthographies). Consequently, phonological deficits of dyslexics are harder to detect in children who have learned to read in transparent orthographies (Vellutino 2004). In these orthographies impairments can be more clearly identified on tasks requiring implicit phonological processing (verbal short term memory, rapid naming, visual-verbal paired associations) (Wimmer et al., 1998, cited in Vellutino et al. 2004) rather than on tasks assessing explicit phonological processing such as phonological awareness and letter-sound decoding.

- Semantic and syntactic skills

It is clear that non-phonological aspects of language, such as semantic and syntactic skills, play an important role in reading comprehension. There is converging evidence that semantic and syntactic skills can also be employed for the process of word decoding (Gallagher et al., 2000; Simpson, 2000; Snowling, 2000, 2005; Bishop and Snowling, 2004; Rispens, 2004). Vocabulary knowledge assists a child to decode a word; it is easier to decode a word when the meaning and the pronunciation of the word is known. Furthermore, knowledge of grammatical structures and categories of words will assist the child in his expectations about the words that are likely to come next, which supports the decoding of printed words. The use of semantic and syntactic context enables a child to decode a word which in turn enhances the experiences of word decoding and provides a child with successful learning trials. This will lead to faster word recognition and to faster and more accurate decoding of words that have

not been encountered before, as grapheme combinations will be recognised automatically (Rispens, 2004).
The importance of semantics is also implied in the reading model of Plaut et al. (1996) that was mentioned above. Nation and Snowling (2004) showed that, in addition to phonological skills, vocabulary knowledge and listening comprehension were unique predictors of reading comprehension and word recognition. These measures also contributed to later individual differences in reading comprehension, word recognition, and exception word reading.
It has been suggested that dyslexic children can use semantic and syntactic skills to compensate for their phonological deficit (Frith& Snowling, 1983; Snowling and Nation, 1998; Olson et al., 1985; all cited in Snowling, 2000; Snowling 2000, 2005; Bishop & Snowling 2004). Dyslexic children have shown deficits in those domains as well.

Wolf & Obregon (1992) and Swan & Goswani (1997) found that dyslexic children performed worse than controls on a picture-naming vocabulary test. However, they argue that those naming deficits result from a phonological deficit rather than from a lexical-semantic deficit, as the dyslexic children showed intact knowledge of the words. Wolf and Obregon (1992) extended the naming task with an auditory multiple choice section that checked comprehension of the pictures the child was unable to name. They concluded that the dyslexic children knew the word, but had trouble retrieving the word. Swan and Goswani (1997) extended the naming task with a visual comprehension task in which the child had to correctly identify the pictures belonging to words it was unable to name. They found a length and frequency effect for the dyslexic group; the longer the word or the lower the frequency of the word, the poorer the performance. In addition, the dyslexic group produced more phonological paraphasias than the other group. Since the results were influenced by phonological variables the authors argue that the naming problems result from a phonological deficit.

Both receptive and productive syntactic difficulties have been found in dyslexics (Mann et al., 1984; Stein et al., 1984; Bar-Shalom et al., 1993; Waltzman & Cairns, 2000; all cited in Rispens, 2004). Also morphological difficulties have been found in dyslexic children (Fowler & Liberman, 1995; Shankweiler et al., 1995, both cited in Casalis et al., 2004; Joanisse et al., 2000; Casalis et al., 2004; Rispens et al., 2003). However, comparisons to reading-level controls (Elbro, 1989; Fowler & Liberman, 1995, both cited in Casalis et al., 2004; Casalis et al., 2004) suggest that the morphological difficulties are largely consequences of poor phonological abilities and lack of reading skill. Also Rispens (2004) notes that reduced exposure to print may interfere with the development of semantic and syntactic skills.

Thus, vocabulary as well as morphosyntactic deficits are observed in dyslexic children. However, it is not clear whether these deficits interfere with reading acquisition or has to be viewed as a consequence of the lag in reading experience that dyslexic children have relative to their typical reading peers.

2.3. Motor skills

Motor problems are frequently observed in dyslexic children (Snowling, 2000, 2005). It is estimated that about 60% of children with reading disability have a developmental coordination disorder or some other problems with motor skills (Viholainen et al., 2002). A developmental coordination disorder, also referred to as dyspraxia, is characterized by difficulties with gross and fine motor movements (Snowling, 2000).

Denckla (1985, cited in Nicolson & Fawcett, 1995) found deficits in speed of tapping, heel-toe placement, rapid successive finger opposition, and accuracy in copying movements. She suggested that dyslexics are characterised by a non-specific developmental awkwardness, which is typically outgrown by puberty. Fawcett and Nicolson found that the motor problems persist into late adolescence. They showed, using a dual task technique, that dyslexic adolescents had problems with balancing (Nicolson & Fawcett, 1990). In another experiment their sample of dyslexic children and adolescents scored below chronological age controls on three tests of motor skill: articulation rate, peg board, and bead threading. For bead threading their performance was even significantly worse than their reading age controls (Fawcett & Nicolson, 1995). Haslum (1989, cited in Fawcett & Nicolson, 1995) found two motor skills tasks which showed significant differences between children with dyslexia and typically achieving children at age 10 years, namely failure to throw a ball up, clap, and catch it again, together with failure to walk backwards in a straight line for six steps. Fawcett & Nicolson (1995) proposed that dyslexic children have problems in skill automatization for any skill, motor or cognitive, but that for most skills dyslexic children learn to mask their incomplete automatization by a process of conscious compensation leading to apparently near-normal performance, at the expense of greater effort. Problems remain apparent in skills requiring rapid performance or fluent interplay of a range of sub-skills. However, failures in replicating motor/automaticity impairments in dyslexic children (Wimmer et al., 1998; Van Daal & Van der Leij, 1999; Kronbichler et al., 2002, all cited in Ramus, Pidgeon & Frith, 2003) contradict this proposal. It is suggested that these impairments might be found only in dyslexics with co-morbid developmental disorders, such as attention deficit/hyperactivity disorder (ADHD) or dyspraxia.

Thus, controversies about the nature of these motor deficits exist. Proponents of the cerebellar and magnocellular theories propose that motor problems are part of dyslexia (Nicolson & Fawcett, 1990; Fawcett & Nicolson, 1995; Stein & Walsh, 1997), whereas proponents of the phonological deficit theory claim that these disorders are co-morbid (Snowling, 2000; Ramus, Pidgeon & Frith, 2003; Ramus, Rosen et al., 2003).

2.4. Concentration

Attentional problems are often observed in dyslexic children (Snowling, 2000). Between 30 and 70% of children with dyslexia also have attention deficit/hyperactivity disorder (ADHD), depending on the setting and how ADHD is defined (Fletcher, Shaywitz & Shaywitz, 1999, cited in Vellutino, 2004). Studies to the prevalence of dyslexia in individuals with ADHD have found percentages between 25 and 40% (Dykman & Ackerman, 1991; McGee & Share, 1988; Semrud-Clikeman et al., 1992; all cited in Wilcutt & Pennington, 2000). Furthermore, data from twin studies have indicated shared genetic aetiology between ADHD and specific decoding problems (Gilger et al., 1992) and between hyperactivity and spelling abilities (Stevenson et al., 1993). Gilger et al. (1992) assessed monozygotic and fraternal twin pairs, in which at least one member was dyslexic. The data suggested that in some cases dyslexia and ADHD may occur together because of a shared genetic aetiology and that a genetically mediated co-morbid subtype may exist. Stevenson et al. (1993) investigated the influence of genetic factors in the co-morbidity of spelling disability and hyperactivity in two samples of same sex twin pairs. They estimated that approximately 75% of the co-occurrence of these two conditions was due to shared genetic influences.

Snowling (2000) argues that poor attention during school lessons is secondary to the reading and writing difficulties rather than reflective of a primary attentional deficit. Also a study by

Pennington et al. (1993, cited in Snowling 2000) implies that the attention problems in children with both dyslexia and ADHD are secondary to their learning difficulties. They found that dyslexic children diagnosed as having ADHD did not show difficulties on executive tasks in contrast to controls with ADHD. In contrast, Reader et al. (1994, cited in Bonafina et al., 2000) did not find significant differences in executive functions between children with ADHD with and without dyslexia. Bonafina et al. (2000) related these controversies regarding differences between the two groups to variance in definitional criteria. They applied a cluster analysis to children's intelligence and reading scores. They found that dyslexic children with ADHD and non-dyslexic children with ADHD differed from each other in cognitive, behavioural and neurochemical functions. This suggests that these groups comprise different subgroups; the behavioural manifestations of ADHD in these groups may be the result of different underlying neural determinants

However, co-morbidity research as well as identifying subtypes of dyslexia or ADHD is done by using categorical definitions (Thomson et al., 2005). Thomson et al. studied the relationship between the attentional system and reading without relying on categorical definitions. They found that an attention factor was significantly related to reading and writing outcome. The attention factor consisted of two components: the ability to ignore irrelevant stimuli to maintain focus and the ability to plan and accomplish goals. The influence of the attention factor was not direct; rather it was mediated indirectly via orthographic and rapid naming factors. They concluded that although dyslexia is primarily a language disorder, multivariate regression, instructional, and brain imaging studies indicate that attention may also play a role in how children learn to analyze and represent the orthographic word form. Directing dyslexic's attention to the orthographic units within written words will facilitate the translating of orthographic into phonological word forms.

Though from the study of Thomson et al. (2005) can be concluded that attention plays a role in reading development and the results of Bonafina et al. (2000) suggested that attentional deficits in dyslexia and ADHD are the result of different underlying neural determinants, it is still not clear whether the attentional deficits are direct consequences of dyslexia.

2.5. Summary

In this chapter evidence for difficulties in the development of language and motor skills and attentional problems in dyslexic children has been described. The most severe deficits are found in phonological processing, particularly in phonological awareness. More subtle deficits are found in the semantic and morphosyntactic domain. Most investigators agree that the reading problems in dyslexia are caused by a phonological deficit, but no consensus exists about the underlying cause of this deficit. Furthermore, it is not clear if the found deficits in the language development of dyslexic children interfere with reading development or are consequences of a failure in reading. Also, more research is needed to find out whether the frequently observed motor difficulties and attentional deficits in dyslexics are co-morbid disorders or has to be seen as consequences of dyslexia.

It is important to find out whether observed differences between dyslexic children and their age peers are direct causes or consequences of reading failure. This is rather complex as until now children are identified as dyslexic if they have tried and failed to learn to read. To counterbalance any effect that reading achievement might have had on various language skills, dyslexic children may be best examined in comparison with reading level matched children in stead of age-matched controls (Casalis et al., 2004; Joanisse et al., 2000; Rispens, 2004). In this way it is possible to get insight in the relationship between reading impairment and semantic or syntactic impairment. However, the comparison between dyslexics and younger reading-level-matched controls may be troubled by differences in cognitive skills depending on age, such as intelligence, attention, and metalinguistic awareness (Rispens, 2004). Another way to tackle this problem is examining children at a genetic risk for dyslexia before school age. This makes it possible to better differentiate those factors that are already present at birth from acquired factors (Lyytinen et al., 2005). In this way early precursors to dyslexia that would be relatively unconfounded by the effects of preschool reading instruction and consequent differences in pre-literacy achievement (Scarborough, 1990), emotional or strategic factors associated with learning, environmental effects on motivation, or interest in reading (Lyytinen et al., 2005). In the next chapter suchlike studies are described. These studies could provide an answer to the question if reading impairments in dyslexic children are preceded by impairments in language development, motor skills, and concentration.

3. Precursors

Several longitudinal studies searching for predictors for dyslexia in language development have been reported. In these studies pre-school children who are at genetic risk, because they have at least one parent or older sibling who is classified as dyslexic, are compared to children without a familial history of dyslexia. Findings of several longitudinal studies concerning the phonological, vocabulary and morphosyntactical development, as well as the motor development of at-risk children will be discussed; in particular Scarborough's (1990) pioneering study, and the findings of three recent projects, namely the Finnish "Jyväskylä longitudinal study of dyslexia" and two longitudinal projects running in the Netherlands: an inter-university research programme "Identifying the core features of developmental dyslexia: a multidisciplinary approach" and a prospective-longitudinal study that takes place at the Utrecht University, entitled "Early language development in SLI and dyslexia: a prospective and comparative study". Next to these some other studies will be discussed.
Attention will also be given to the interesting finding of subtle problems in the language and literacy development of at-risk children who do not develop dyslexia. Finally, predictors in language development that contribute to reading development will be discussed.

3.1. Phonological Development

The majority of the studies searching for predictors have focussed on phonology. This is not surprising as phonological deficits are the most consistently reported deficits in dyslexics. Several studies have found differences in phonological development, both in input and output processing, between children at risk for dyslexia and controls (Scarborough, 1990; Gallagher et al., 2000; Pennington and Lefly, 2001; Snowling et al., 2003; Carroll and Snowling, 2004; Lyytinen et al., 2004; Van Alphen et al., 2004; Wijnen et al., 2005).

All those studies found deficits in phonological awareness (rhyme knowledge, phoneme matching, identification and blending of phonological units) and verbal short term memory (digit span, (non)word repetition, nonword learning). Furthermore, deficits were found in speech perception (Carroll and Snowling, 2004; Lyytinen et al., 2004; Van Alphen et al., 2004; Wijnen et al., 2005), particularly in categorical perception of consonants and detection of mispronunciations. The Jyväskylä study was unique in focusing on speech perception by measuring brain event related potentials (ERPs) in infants. It was found that at-risk and control newborns responded differently to various features of speech sounds, such as vowel duration change (/ka/, /kaa/) and CV syllables (/ba/, /da/, /ga/). Also 6-month-old at-risk infants differed from controls in change-detection response to consonantal duration differences. The experiments revealed hemispheric differences between the groups. The at-risk group showed an enhanced right hemispheric processing of speech sounds. The change detection was observed more consistently in the right hemisphere in the at-risk group, whereas in the control group, this pattern occurred in the left hemisphere.

Deficits were also found in productive phonology. Scarborough (1990) found that 2-year-old at-risk children had less accurate consonantal pronunciation of words, whereas a phoneme discrimination task did not reveal a receptive phonological impairment before the age of 3 years. Wijnen et al. (2005) found that 4-year-old at-risk children showed more simplifying phonological processes in a naming task, which was measured by counting the occurrence of syllable deletion, cluster reduction, and fricative and dorsal consonant avoidance. 62% of the at-risk children were labelled as poor performers, whereas only 10% of the controls performed poorly. No qualitative differences were found between the groups, but significant differences were found for cluster reduction and fricative avoidance. Interestingly, the at-risk children who were most delayed in productive phonology also performed poor on a categorical perception task. Also Caroll and Snowling (2004) found that speech production difficulties were more common in the at-risk group. In contrast, Gallagher et al. (2000) and Snowling et al. (2003) did not find differences in articulatory accuracy between at-risk children and controls. This contradiction could be due to differences in age; the subjects of Scarborough's (1990) and Wijnen et al.'s (2005) studies are slightly younger than those of Gallagher et al.'s (2000) and Snowling et al.'s (2003) study. It could also be due to differences in sample size or in the measures applied.

Taken together, the reported studies support the suggestion made by Pennington and Lefly (2001), that the phonological phenotype in children who become dyslexic is clearly broader than it is at later ages, i.e. it involves a variety of phonological skills. At later ages the main phonological deficit found in dyslexic people is in phoneme awareness, whereas few differences between dyslexics and non dyslexics are found in the other domains of phonological processing.

3.2. Lexical development

Children at risk for dyslexia show delays in lexical development, both in expressive and receptive vocabulary (Scarborough, 1990; Lyytinen, Poikkeus et al., 2001; Gallagher et al., 2000; Snowling et al., 2003; Carroll and Snowling, 2004; Lyytinen et al., 2004; Lyytinen & Lyytinen, 2004; Koster et al., 2005). Generally speaking, the delays seem to increase with increasing age, as the delays in older children are more consistently reported. Some inconsistency exists about the age at which the delays can be found.

In the Jyväskylä study no differences in milestones of vocalization, language comprehension and production were found between at-risk children and controls (Lyytinen, Ahonen et al., 2001). However, several studies found that at-risk children are more likely to become late talkers than controls. Koster et al. (2005) found that an at-risk group comprised approximately twice as many late talkers than a control group. Snowling et al. (2003) reported that 38% of the at-risk children were late talkers. In the Jyväskylä study was found that at-risk late talkers scored significantly below age peers on productive and receptive language measures at age 3y6m (y=years, m=months), whereas control late talkers generally caught up by this age (Lyytinen, Poikkeus et al., 2001). Koster et al. (2005) and Snowling et al. (2003) do not mention the criteria used for defining a child as a late talker. Lyytinen, Poikkeus et al. (2001) classified a child as a late talker if it scored more than one standard deviation below the mean of standardized scores on three expressive language measures at the age of 2 years.

Scarborough (1990) and the Finnish investigators (Lyytinen, Poikkeus et al., 2001, 2004; Lyytinen & Lyytinen, 2004) did not find differences in expressive vocabulary of at-risk children before the age of 3 years, while Koster et al. (2005) found quantitative and qualitative differences in productive vocabulary at the early age of 17 months. The at-risk children had a significantly lower number of total acquired words. Moreover, at-risk children with productive vocabularies larger than 50 words produced significantly fewer verbs and closed-class words than controls, while no differences were found for common nouns and other predicates. Furthermore, growth-curve analysis of 17- and 23-month-old children showed that the differences between the control and at-risk children increased significantly over time

Scarborough (1990) found differences in receptive vocabulary from the age of 3 years onwards, whereas the Finnish investigators did not find receptive delays before age 5 years (Lyytinen et al., 2004). Carroll and Snowling (2004) did not find receptive delays in their sample of 4- to 6-year-old at-risk children, whereas Gallagher et al. (2000) and Snowling et al. (2003) found poorer receptive vocabulary deficits in 3y9m-old at-risk children.

A possible explanation for these inconsistencies is the difference in the measures that were applied. It could be that they differ in sensitivity. Koster et al. (2005) used an inventory, while Scarborough (1990) used standardized tests. However, this cannot explain the differences in results between the Jyväskylä study and the study of Koster (2005), as the same inventory was used in the Jyväskylä study. Also the inconsistent results of Carroll and Snowling (2004) and Gallagher et al. (2000) and Snowling et al. (2003) cannot be explained by difference in used measures, nevertheless they can be explained by differences in sample size. The at-risk sample of Carroll and Snowling (2004) was rather small comprising 17 children, whereas the samples of Gallagher et al. (2000) and Snowling et al. (2003) compromised 63 and 56 children, respectively. It could be that no significant differences were found in the study of Caroll and Snowling (2004) because of lower power due to the small sample size. Furthermore, Gallagher et al. (2000) and Snowling et al. (2003) split the at-risk group up into a literacy impaired and a literacy unimpaired group, while Carroll and Snowling (2004) analyzed the results of the at-risk group as a whole.

3.3. Morphosyntactic development

Delays have been found in the morphosyntactic development of at-risk children. Most studies concentrated on productive differences between at-risk children and controls, but also receptive differences have been found.

The Jyväskylä study (Lyytinen, Poikkeus et al., 2001), the Utrecht study (Van Alphen et al., 2004; Wilsenach & Wijnen, 2004; Wilsenach, 2006) and the inter-university Dutch study (Koster et al., 2005) started assessing the morphosyntactic development from at-risk children and controls as young as 18 months. The earliest group differences were found in the Utrecht study, which was special in using the preferential listening procedure to assess perceptual sensitivity to morphosyntactic agreement. The ability of 19-month-old at-risk children and controls to recognise the dependency between the temporal auxiliary 'heeft' (has) and the past participle was assessed. It was tested whether the children were able to discriminate this from a distorted dependency in which 'heeft' was replaced by the modal auxiliary 'kan' (can). It was expected that sensitivity to this dependency would reveal itself in a preference for the passages in which the dependency is maintained. The absence of a clear preference, however, would imply a reduced sensitivity to this dependency. The results showed that the at-risk group, in contrast to the control group, failed to recognise the grammatical dependency between the auxiliary and the past participle at the age of 19 months (Wilsenach, 2006; Wilsenach & Wijnen, 2004; Van Alphen et al., 2004) and did not show evidence of catching up with controls at the age of 25 months (Wilsenach, 2006). These results imply that at-risk children, compared to age-matched controls, are less sensitive to the pattern in which the grammatical morphemes 'heeft' (has) en 'ge' (past participle prefix) can occur in Dutch (Van Alphen et al., 2004; Wilsenach, 2006).

The ability to discriminate well formed from ill formed morphosyntactic dependencies was also assessed in slightly older samples. Wilsenach (2006) found that 5-year-old at-risk children and controls were equally sensitive to the dependency between the auxiliary 'heeft' (has) and the past participle, and the dependency between the modal ‘kan’ (can) and the infinitive. However, a subset of the at-risk children had striking difficulties in discriminating sentences with the auxiliary ‘heeft’ and the past participle from sentences with a bare participle (Wilsenach, 2006). In contrast, Rispens (2004) found that 5- and 6-year-old at-risk children were less sensitive to subject-verb agreement than controls. There are two differences between the studies that may explain these contradictory findings. First, different grammatical dependencies were studied. Second, there could be a difference in sensitivity of the tasks used in the two studies. Rispens used a grammatical judgement task, in which subjects had to give a conscious judgement of the syntactic structure itself, whereas Wilsenach used a discrimination task in which the children had to say whether two sentences were different or not.

In the Jyväskylä study the earliest found difference between at-risk children and controls was sentence length at age 24 months. The mean number of morphemes produced in utterances was lower among at-risk children. Similarly, Koster et al. (2005) found that 23-month-old at-risk children had significant shorter mean length of longest utterances (MLUL), measured for words and morphemes, as compared to controls. Furthermore, they found that at-risk children were less likely to develop the ability to combine words into utterances between 17 and 23 months of age than controls. Significantly shorter and less syntactically complex sentences were also found in slightly older children aged between 2y6m and 4 years (Scarborough, 1990) and 3y9m and 6 years (Gallagher et al., 2000; Snowling et al., 2003). Snowling et al. (2003) found also that 6-year-old at-risk children, compared to controls, had more difficulty correcting word order of jumbled sentences and recalling sentences ranging from short active sentence to long sentences containing embedded clauses. Furthermore, delays in inflectional morphology (Lyytinen, Poikkeus et al., 2001; Van Alphen et al., 2004; Wijnen et al., 2005; Wilsenach, 2006) and derivational morphology (Lyytinen, Poikkeus et al., 2001) have been found in at-risk children.

Scarborough (1990) found that the deficits in comprehension and production of syntactic structures and morphemes marking morphosyntactic information dissolved at the age of 5 years. This may indicate that dyslexic children are delayed in the development of morphosyntax, but catch up around the age of 5 years (Scarborough, 1990). It is also possible that no difference between the groups was observed because the children reached a temporary plateau in their track of language development; the differences may re-emerge at a later age.
However, studies that demonstrated morphosyntactic deficits in older at-risk children (Lyytinen, Poikkeus et al., 2001; Snowling et al., 2003; Rispens, 2004) suggest that the choice of methodology accounted for the observed recovery of the delay in the study of Scarborough (1990). It could be that the measures used, the Index of Productive Syntax and mean length of utterances (MLU), are less suited methods to measure the syntactic performance of 5-year-old children than that of younger children.

The Utrecht study found that at-risk children showed morphosyntactic difficulties especially in sentences containing complex argument structures (Van Alphen et al., 2004; Wijnen et al., 2005; Wilsenach, 2006). This implies that the productive abilities of at-risk children are affected by an increased processing load. The processing capacity was manipulated by using intransitive, transitive and ditransitive structures. It was assumed that transitive verbs require a higher processing capacity than intransitive verbs, because next to the expression of a subject also an object has to be expressed. A ditransitive verb is expected to require an even higher processing capacity, as it requires the expression of an additional indirect object. The finding that the at-risk children scored poorest in the most complex structures suggests that the differences between the two groups do not rely on a difference in morphosyntactic competence, but must probably be attributed to a difference in processing (Wijnen et al., 2005).

3.4. Motor development

Very little is known about early motor development in children who will develop language or reading disorders. The few studies that looked at the early motor development of children with speech and language problems found that those children were delayed in their early motor milestones, especially in independent walking (Robinson, 1987, Haynes and Naidoo, 1991, Traner et al., 2000; all cited in Viholainen et al., 2002). Within the Jyväskylä study Viholainen et al. (2002) focussed on the relation between early motor and language skills in children at risk for dyslexia. The infants' progress through stages of motor development was followed during the first two years of life by using structured parental questionnaires. Expressive language skills were assessed at the age of 18 and 24 months No significant differences were found in gross or fine motor development and language measures between the at-risk group and a control group. However, cluster analyses revealed a different pattern in those groups. In the at-risk group two patterns were found: 'fast motor development' and 'slow motor development'; while in the control group three patterns were found: 'fast motor development', 'slow gross development', and 'slow fine development'. Furthermore, there seemed to be an association between motor and language difficulties in the at-risk group, while no such relationship was found in the control group. Children in the at-risk group who had a slow motor development had a smaller vocabulary and produced shorter sentences. So there is a subgroup of children among those born at familial risk for dyslexia whose slow early motor development is accompanied by a delay in language development later. The authors argue that the connection between motor and language development in the at-risk group could be explained by the hypothesis that learning new skills is not as easy for children with dyslexia as it is for typically developing children. The slow gross and fine motor development can be interpreted as an early sign of a problem in learning new skills. A similar kind of learning problem was observed in their language development at 18 and 24 months.
The at first sight strange association between motor development and language development is also assumed in the declarative/procedural (DP) model of language, proposed by Ullman (2004). According to this model language development is subserved by the brain systems underlying declarative and procedural memory. The declarative memory system underlies the storage and use of knowledge of facts and events. The procedural memory system supports the learning and execution of motor and cognitive skills, especially those involving sequences. These systems are also implicated in language functions; lexical memory depends largely on the declarative memory system, whereas aspects of grammar depend on the procedural memory system. This model predicts an association between morphosyntactic and motor skills, as those skills depend both on the brain structures underlying procedural memory.

3.5. Concentration

Although attention problems are often associated with dyslexia, no studies which investigated concentration in children at risk for dyslexia could be found in the literature.

3.6. Continuity

It seems likely that only the subgroup of at-risk children who will later develop dyslexia experiences problems in the previous described areas. However, several studies have suggested otherwise. These studies found that children at high risk for developing dyslexia performed worse than controls on several tasks even if they did not develop dyslexia. This suggests continuity of the distribution of reading difficulties. For example, Elbro et al. (1998) found that Danish at-risk children who did not develop dyslexia were impaired on morpheme deletion and articulatory accuracy and efficiency before reading age, whereas those who later became dyslexic had additional deficits in letter naming, phoneme awareness, verbal short term memory and distinctness of phonological representations. Support for continuity was also found by Pennington & Lefly (2001) who found that the at-risk group who did not develop dyslexia scored significantly lower on most measures of reading and spelling, and had more difficulty on tests of implicit phonological processing (verbal short term memory and rapid serial naming), although they were unimpaired on tasks tapping explicit phonological awareness.

Similarly, Snowling et al. (2003) found that non-dyslexic at-risk children, in contrast to the later dyslexics, did not show impairments in non-phonological language skills including vocabulary and expressive grammar, but their performance on tests of written language was in between that of later dyslexics and controls and they were as impaired as the later dyslexics on tests requiring transcoding between letters and sounds. Weaknesses on literacy skills were still present at the age of 8 years; although the non-dyslexic at-risk children did not fulfil criteria for literacy impairment, they showed poorer spelling, nonword reading and reading comprehension than controls. In line with this, Lyytinen et al. (2004) found that the better half of the at-risk group that was expected to be non-dyslexic, in comparison with the better half of the control group was significantly less advanced in early reading (Lyytinen et al., 2004).

In contrast, the results of Scarborough (1990) and Gallagher et al. (2000) do not support this continuity, as their results do not show differences between the at-risk children who did not develop dyslexia and typically developing children. However, these controversies may be explained by differences in diagnostic criteria for dyslexia or differences in sample size (Pennington & Lefly, 2001). The samples of Scarborough (1990) and Gallagher et al. (2002) contained less non-dyslexic at-risk children than the samples of the studies that found differences between non-dyslexic at-risk children and controls. Another possibility is that the difference between the groups can be found from the age of 5 years onwards, but not before the age of 5 years, as the studies failing to provide evidence for continuity focused on children between the ages of 2 and 5 years, whereas the studies suggesting continuity focused on children between the ages of 5 and 7 years.

To account for the contradictory finding that non-dyslexic at-risk children have deficits in grapheme-phoneme skills but go on to be classified as typical readers, Snowling et al. (2003) proposed that the at-risk children who did not develop dyslexia have been able to compensate for their deficits. They argue that better vocabulary development may facilitate the development of segmental representations and, consequently, phonemic awareness. It seems that good phonemic skills protected the at-risk children from the reading failure that might have been expected given their poor grapheme-phoneme skills. Thus, the risk of dyslexia is continuous. The outcome of reading development in at-risk children depends not only on the severity of the phonological deficit, but also on the development of non-phonological language skills. At-risk children with good vocabulary and wider language skills are more likely to compensate for the phonological deficit and to become typical readers.

3.7. Predictors

Several precursors in the language development of at-risk children have been described in the previous part of this chapter. However, this does not mean that all those precursors indeed affect the reading development in those children. It is important to evaluate the predictive value of these precursors. In this part several studies that have identified significant predictors for variance in reading outcome will be described. It is important to keep in mind that predictors have to be distinguished from causes or explanations of reading difficulties. As predictors are simply correlates, they should be considered as associated conditions implicated in reading difficulties (Snow et al., 1998).

Scarborough (1990) found that syntactic and phonological deficits at age 2 years emerged as earliest precursors, with the syntactic differences corresponding most closely with children's eventual reading outcomes. At later ages slow vocabulary growth, poor naming and poor letter knowledge could be identified as predictors.

In line with this Gallagher et al. (2000) found that letter knowledge as well as measures of speech and language at 3y9m, together with performance IQ, were independent predictors of literacy skills at 6 years. Measures of speech and speech processing were only marginally stronger predictors of literacy than syntactic and semantic skills. The strongest predictor of literacy at 6 was letter knowledge at 3y9m. Also Pennington and Lefly (2001) and Rispens (2004) found that letter knowledge was the most powerful predictor of reading in an at-risk group.

Elbro et al. (1998), who tested the predictive value of phonological processing skills in at-risk children, found that letter naming, phoneme identification and distinctness of phonological representations predicted if an at-risk child became dyslexic or not. Moreover, it was shown that distinctness of phonological representations contributed significantly to phonological awareness, suggesting that this is at least one of the factors underlying the development of phonological awareness.

In the Jyväskylä study symbolic play at 14 months, receptive language measured by the Reynell at 2y6m, digit span at 3y6m, phonological segmentation of phonemic units at 4y6m, and letter identification at 5y5m were found to be significant predictors of school entry decoding (Lyytinen et al., 2004). Furthermore a language skills factor consisting of 14-month receptive vocabulary, 18-month comprehension, and 30-month receptive and productive language and inflectional skills, was found to be a significant predictor of phonological awareness at 3y6m. Strong correlations were found between early reading skills and acquisition of phonological structure. Children who ended up as good readers at school entry had been significantly more advanced than intermediate or poor readers in their production of word length and syllable structures, as well as in some phoneme combinations at 2y6m (Lyytinen et al., 2004).

Only a few studies tested the degree of similarity of predictors of normal and extreme variation in literacy skill directly. Gallagher et al. (2000) found that letter-name knowledge was the strongest predictor in both groups, but performance IQ and a language factor were predictive only in the at-risk group, whereas a speech factor (articulation and nonword repetition) was predictive only in the control group. Also Pennington & Lefly (2001) found these somewhat different predictors of reading and spelling skills in the at-risk and control group. Though, they note that this may simply reflect that the two groups are at different stages on the same developmental pathway. For the control group phonological awareness was the main and usually only predictor and prediction did not vary much by age or literacy outcome measures. In contrast, for the at-risk group prediction varied markedly by age but not by outcome measure. This group underwent a shift from letter-name knowledge to phonological awareness. So it depends on the age whether the predictors of literacy vary. De Jong and Van der Leij (1999) found that the predictive value of phonological awareness may vary as to where the children are in their stage of reading acquisition. Scarborough's study (1990) suggests an earlier shift in the dyslexic group; from a deficit in expressive syntax to a phonological deficit. According to Pennington & Lefly (2001), this suggest that the genes that influence dyslexia may transiently affect other aspects of language development, in addition to their well-documented affects on phonological development

Some notes have to be made regarding the accuracy of these predictors. These predictors do explain variability in reading development, but they should not be interpreted as highly accurate predictors of dyslexia. For example, Pennington & Lefly (2001) found that reading disability could be predicted with a moderate accuracy at age 5 years, with the strongest predictor being letter-name knowledge. Furthermore, when comparing predictors of reading development across different languages it is important to keep in mind that these predictors differ across languages, particularly phonological awareness, because of differences in regularity of orthography. Phonological awareness has been found to be a more consistent predictor of reading development in an opaque orthography than a transparent orthography (Snowling, 2000; Vellutino et al., 2004; see chapter 2). Moreover, not necessarily all children who experience problems in a language with an irregular orthography will have difficulties in reading acquisition in a more regular orthography (Lyytinen et al., 2004).

3.8. Summary

In general, the studies summarised above provide evidence that dyslexia is preceded by phonological, lexical, and morphosyntactic deficits. During the preschool period deficits can be found in a variety of phonological skills and also outside the phonological domain, whereas in school-age and adult dyslexics deficits are typically found in phonological awareness. Furthermore, these studies show that the subtle semantic and morphosyntactic problems observed in dyslexic children (see chapter 2) cannot simply be viewed as consequences of reading failure. Some of these studies suggest that speech perception is affected. The observed deficits on the categorical perception tasks (Wijnen et al., 2005, Van Alphen et al. 2004, Lyytinen et al., 2004) suggest that children at risk for developing dyslexia have less sharply defined phoneme boundaries, which is in line with reported categorical perception performance of dyslexic children and adults (Wijnen et al., 2005; Van Alphen et al., 2004; Serniclaes et al., 2004, Vellutino et al., 2004). The studies of Lyytinen et al. (2004) show that at-risk children differ in categorical perception right after birth. This implies that speech perception is affected by genetic factors in familial dyslexia. A fuzzy auditory perception leads to insufficiently specified phonological representations, which could explain the observed worse performance in the other domains of phonological development. Lexical and morphosyntactic deficits could also be explained by the affected speech perception. Speech perception problems affect the ability to benefit from environmental speech and language, which affects the development of receptive and expressive language abilities. Moreover, it turned out that semantic and syntactic skills next to phonological skills indeed explain variability in reading development. As noted by Snow et al. (1998), these predictors can be very useful for identifying children who are at high risk of reading difficulties. This makes it possible to set up early interventions to prevent or minimize reading difficulties for these children. Though, it is not the case that treating the predictor itself is necessarily the right approach. Furthermore, it seems that familial risk is continuous rather than discrete, as subtle impairments are also found in at-risk children who do not develop dyslexia. However, they seem to be able to compensate for these deficits, as they do not experience severe reading problems.

However, it has to be taken into account that studying children at genetic risk for dyslexia is quite different from studying children classified as dyslexic (Snowling, 2000). These two groups differ because usually only some of the dyslexic children participating in studies have a familial history of dyslexia. It could be possible that in the studies with dyslexic children exclusion criteria have lead to exclude dyslexic children with vocabulary impairments. This could explain why in dyslexic children only subtle vocabulary deficits are found, whereas the problems in at-risk children are more pronounced. Moreover, it is likely to be the case that dyslexic children recruited following reading failure will have more severe deficits than those whose difficulties are identified early. Another possibility is that vocabulary deficits may be a consequence of the phonological processing impairment. It could be that young children who will develop dyslexia have in particular problems to acquire phonological forms. Later on they are able to catch-up on receptive vocabulary by inferring the meanings of new words, whereas expressive vocabulary deficits persist.

Several questions arise from the studies summarized. In the next chapter a new study is described which aimed to answer the question why 19-month-old at-risk children fail to recognize discontinuous morphosyntactic dependencies. This study also tried to answer the question if these toddlers show deficits in lexical development, motor development and/or concentration. Until now, little is know about the motor development of at-risk children and some inconsistency exist about the age at which deficits in the lexical domain can be found. To my knowledge, no study has assessed the ability to concentrate in at-risk children. This study was also special in trying to find relationships between sensitivity to morphosyntactic dependencies and language development, general development, motor development and concentration.

4. Study: Language and motor development in children at risk for dyslexia

4.1. Motive

The study of Wilsenach and Wijnen (2004) gave rise to this study. They found that 19-month-old at-risk children, in contrast to age peers without a genetic risk, were not able to discriminate between grammatical and distorted dependencies in passages containing a two-syllable adverb between the auxiliary and past participle. Furthermore, the at-risk children did not show evidence of catching up at the age of 25 months. These results imply that children at risk for developing dyslexia have difficulty to detect the morphosyntactic dependency between the grammatical morphemes ‘heeft’ (has) and ‘ge’ (past participle prefix). The behaviour of the at-risk children can be explained in two ways.

The first explanation is that those children are not sensitive to the pattern in which the grammatical morphemes ‘heeft’ and ‘ge’ can occur in Dutch. They do not have the knowledge (yet) to discriminate between the passages. This could either be due to a delay or a deficit in the acquisition or recognition of grammatical structures. This suggests that children at risk for dyslexia have considerable problems in discovering the grammatical structure of their native language, which may affect their language production (Wilsenach, 2006; Wilsenach & Wijnen 2004; Van Alphen et al., 2004). This explanation is in line with the reported deficits found in the semantic and morphosyntactic development of at-risk children (see chapter 3). However, some of these studies have suggested that the deficits could be related to differences in processing (Wijnen et al., 2005; Wilsenach, 2006), which is more consistent with the explanation described below.

The alternative explanation is that the at-risk group is able to detect the discontinuous dependency; but that their ability to detect this dependency is more limited than that of typically developing children. In order to recognize the dependency between the auxiliary ‘heeft’ and the past participle, an infant must have a large enough processing window to be able to compute the co-occurrence of these morphemes over the intervening two-syllable adverb. The processing window refers to the amount of linguistic information that a child can process at a given moment in time (Wilsenach, 2006). According to this explanation the inability to discriminate the passages is due to a processing deficit.

Santelmann and Jusczyk (1998), Höhle et al. (2004) and Wilsenach (2006) found that the ability of typically developing children to detect a discontinuous dependency is limited. Santelmann and Jusczyk (1998) investigated typically developing English-learning children’s perceptual sensitivity to the morphosyntactic dependency between the auxiliary ‘is’ and the progressive suffix ‘–ing’. They found that 15-month-old children were not able to discriminate this from a distorted dependency in which the auxiliary ‘is’ was replaced by ‘can’, whereas 18-month-old children discriminated between the normal and distorted dependency by listening longer to sentences containing the normal dependency. Furthermore, they varied the distance between the dependent morphemes by inserting adverbials of different length. The 18-month-old children showed preference for the well-formed dependency only over a limited domain of 1-3 syllables; no significant preference was found over domains of 4-5 syllables. They concluded that 18-month old children worked with a limited processing window.

Santelman and Jusczyk’s (1998) result was replicated by Höhle et al. (2004) with 19-month old German children. They used a grammatical dependency similar to the one used by Wilsenach and Wijnen (2004), namely the dependency between the auxiliary ‘hat’ (has) and the past participle (prefix 'ge-'). They found that German children preferred to listen to the grammatical passages, provided that no more than two syllables intervened between the dependent morphemes. This implies that the processing window of German children aged 19 months is limited to a domain of two syllables. The difference in size of the processing window between English and Dutch age peers may be related to the fact that German is verb-final, whereas English is verb-second (Höhle et al. 2004).

Similar findings were found by Wilsenach (2006) for Dutch-learning children. She conducted an experiment which aimed to determine the effect of an increased processing load on the ability of typically developing children, aged between 24 and 30 months, to recognize a discontinuous morphosyntactic dependency. In this experiment the distance between the dependent morphemes was increased to four syllables. Although, syntactically speaking, the insertion of a two-syllable adverb does not cause the sentence to be more complex, Wilsenach (2006) argues that the insertion of an extra two-syllable adverb made the task more difficult because it creates a "real-time" obstruction between the auxiliary and the past participle, which increases the processing load. The results revealed no significant differences in listening time to the grammatical and ungrammatical passages. Apparently, the children were unable to discriminate between the grammatical and ungrammatical passages when the distance between the dependent morphemes was four syllables. This implies that typically developing children's processing window is limited (Wilsenach, 2006).

It could be that children at risk for dyslexia have a smaller processing window as compared to age peers (Wilsenach, 2006). The separation of the two dependent morphemes by a two-syllable adverb affected the recognition of the dependency and the fact that the at-risk group failed to discriminate between the grammatical and ungrammatical passages in the experiment should be ascribed to a deficit in working memory. The 'processing deficit explanation' is in agreement with findings that suggest verbal working memory deficits in both children and adults with dyslexia. These deficits have been observed in performance on digit span tasks, recall tasks, word and pseudoword repetition tasks (see Rispens, 2004 and Wilsenach, 2006 for an overview). In addition, Wilsenach (2006) found that a subgroup of at-risk children performed poorer on a digit span task in comparison to controls. More generally, language impairments have often been related to limited processing capacity (see Santelmann & Jusczyk, 1998 and Wilsenach, 2006) and children with good phonological working memory skills generally have better language skills in comparison to children with poorer phonological working memory skills (Wilsenach, 2006).

On the other hand, it has also been suggested that a limitation in processing space facilitates language acquisition (Newport, 1988, 1991; Elman, 1993, both cited in Santelmann & Jusczyk, 1998). Limits in processing space may promote language learning by creating a restrictive filter for the input data. Because the filter focuses the input data, the number of possible form-meaning co-occurrences reduces. This enables a child to easily acquire the basic dependencies in the language to be acquired. Once these basic dependencies between morphemes are acquired, the learner can then apply this knowledge to help decode longer, more complex structures.

These contradictory ideas can be brought into line if it is assumed that the growth of the processing window is a developmental process. The growth of the processing window enables a child to learn to recognize all dependencies; basic as well as longer and more complex dependencies. Knowledge of these relationships is crucial for being able to structure and decode language (Santelmann & Jusczyk, 1998). A delay or deviation in the development of the processing window interferes with the ability to understand or create these relationships. This leads to deficits in language comprehension and production. Thus, it is a delay or deviation in the development of the processing window that has to be related to language impairments. Due to this delay or deviation the processing window is more limited in children with language impairment, as compared to typically developing age peers.

The main aim of the present study was to find out which of the two explanations is the most plausible. Therefore two preferential listening experiments were conducted with at-risk children and typically developing children. Wilsenach and Wijnen (2004)'s experiment was replicated to ensure that the new sample performed similarly; in contrast to control children, the at-risk children should not be able to detect a distorted dependency if a two-syllable adverb intervened between the dependent morphemes. To find out in what way this behaviour should be explained a second experiment was conducted in which the two dependent morphemes were as close to each other as possible, namely adjacent to each other. This experiment was a replication of an experiment by Van der Ven (2004), which was inconclusive due to a limited sample size. The replication of the experiment by Wilsenach and Wijnen (2004) will be referred to as the experiment with intervening adverb and the replication of the experiment by Van der Ven (2004) will be entitled the experiment without adverb.

Another aim of this study was to identify possible differences in early language and motor skills and concentration between the two groups of children participating in the preferential listening experiments, since in the literature problems in these domains are associated with dyslexia (see chapter 2). From chapter three can be concluded that delays can be found in early language development of at-risk children, but little is known about motor development and concentration in those children. A language test, inventories, questions about general development and observations were used to assess early language and motor skills and concentration.

Of special interest was if relationships could be found between the preferential listening results and measures of general development, language development, motor development and concentration. Previous studies showed that the processing window of typically developing children increases with increasing age (Santelmann & Jusczyk, 1998; Höhle et al., 2004; Wilsenach, 2006), which implies that older toddlers are more likely to show a preference for grammatical stimuli. Furthermore, as the growth of the processing window is a developmental process, it seems plausible to expect that toddlers who have a better general development are more likely to discriminate between the passages.

Sensitivity to grammatical structure is assumed to be related to productive and receptive language skills (Wijnen et al., 2005; Wilsenach, 2006). This implies that children with good language skills are more likely to have a preference for grammatical stimuli, whereas children with poor language skills are more likely to have no preference. Santelmann and Jusczyk (1998) found an association between language production and sensitivity to morphosyntactic dependencies. Children who had begun to produce two-word combinations were more likely to show sensitivity to morphosyntactic dependencies than children who had not yet begun to combine words.

Motor problems are frequently observed in dyslexics (see chapter 2). Furthermore, Viholainen et al. (2002) found an association between language and motor difficulties in at-risk children but not in control children (see chapter 3). Therefore, it is expected that motor skill variables are associated with the preferential listening results in the at-risk group, but not in the control group. In a similar way a relationship between concentration and preferential listening could be plausible.

4.2. Research questions and hypotheses

Preferential listening

The following research questions had to be answered in order to find evidence for the right explanation:

- Does the new sample of children perform similarly to the sample of Wilsenach and Wijnen (2004) in the preferential listening experiment with intervening adverb?
    - Do typically developing children show preference to grammatical dependencies?
    - Do at-risk children show preference to grammatical dependencies?
- Can at-risk and control children discriminate between correct and distorted morphosyntactic dependencies when the dependent morphemes are adjacent to each other?
    - Do typically developing children show preference to grammatical dependencies?
    - Do at-risk children show preference to grammatical dependencies?

It was expected that the new sample would perform similar to the sample of Wilsenach and Wijnen (2004) in the experiment with intervening adverb. The typically developing children were expected to prefer grammatical passages by having significantly longer listening times to grammatical passages. The at-risk children are expected to show no preference.

In the experiment without adverb it is expected that the typically developing children perform similar as in the experiment with intervening adverb. The expectation is that they show a preference for the grammatical passages. Concerning the at-risk group two hypotheses are possible dependent on which explanation is the most likely. If the at-risk children are indeed unable to recognise the grammatical dependency they are expected to show no preference for grammaticality again. If, however, at-risk children have a smaller processing window they are expected to prefer grammatical passages in this experiment.

Language and motor skills and concentration

With regard to the development of general language and motor skills and concentration the following research questions had to be answered:

- Do language skills of at-risk children and typically developing age peers differ?
    - Do at-risk children score below controls on receptive language measures?
    - Do at-risk children score below controls on productive language measures?
- Do motor skills of at-risk children and typically developing age peers differ?
- Do at-risk children and typically developing age peers differ with regard to their ability to concentrate?
    - Do at-risk children sustain attention during the tests?
    - Do typically developing children sustain attention during the tests?
    - Do at-risk children pay attention to what is being said to them during the tests?
    - Do typically developing children pay attention to what is being said to them during the tests?

From the literature it can be concluded that at-risk children as well as dyslexic children show problems in these domains. Consequently, it was expected that the at-risk group would show delays in language and motor development and poorer concentration, and that they score below controls on these measures.

Relationships

To identify possible relationships between the preferential listening results and age, general development, language skills, motor skills and concentration the following research questions had to be answered:

- Is there an association between the preferential listening results and any of the single variables
    - in the at-risk group?
    - in the control group?
- Do the language variables taken together explain variability in the preferential listening results
    - in the at-risk group?
    - in the control group?
- Do the non-language variables taken together explain variability in the preferential listening results
    - in the at-risk group?
    - in the control group?
- Do both language and non-language variables explain variability in the preferential listening results
    - in the at-risk group?
    - in the control group?

All these questions will be addressed for both experiments separately.

As sensitivity is assumed to be related to language skills (see above), it is expected that all language skills will be correlated to the preferential listening results in the control group. On the basis of this, it is also expected that the language variables together explain a considerable part of the variability in the preferential listening results. A child with good language skills is expected to show better results on the preferential listening experiments than children with poor language skills. This is also expected for the at-risk group if the 'delayed knowledge' explanation is the right one. The association is expected to be even stronger due to the fact that the at-risk group comprises two subgroups (a later dyslexic and a later non-dyslexic group). The later dyslexic subgroup is expected to show lower scores on both the language measures and the preferential listening experiments, whereas the later non-dyslexic subgroup is expected to perform better on these measures. This leads to a particularly high within-group variation for these measures in the at-risk group. In the control group the within-group variation is expected to be smaller, as the controls are expected to score more similar to each other. However, if the 'processing deficit' explanation turns out to be the right one, it is expected that the association between the language measures and the preferential listening results is less clear in the at-risk group than in the control group. The preferential listening results in the at-risk group are then expected to be more independent from the results on the language measures. In this case the at-risk children have the required knowledge to show preference for grammaticality, but do not show preference due to a processing deficit. This suggests that they will perform well on the language measures, but not in the preferential listening experiment.

As preference for grammaticality is related to general development and age (see above), preference for grammaticality is expected to correlate with those variables in both groups.

On the basis of the frequent occurrence of motor problems in dyslexics and on the found association between language and motor difficulties in at-risk children (Viholainen et al., 2002), it is expected that motor skill variables are associated with the preferential listening results in the at-risk group, but not in the control group. A similar expectation holds for an association between concentration and preference for grammaticality.

4.3. Method

Participants

In order to recruit participants, posters were sent to all Dutch health centres for young children and to day-care centres and play groups in and around the city of Utrecht. Posters were also displayed in supermarkets, baby shops, and toy libraries. Furthermore, advertisements were placed in magazines and at internet sites directed to people with dyslexia and parents of young children. In addition, parents who had participated with a child in other dyslexia studies at the Utrecht Institute of Linguistics OTS were contacted. This resulted in a group of 29 participants who were divided into two groups: an at-risk group and a control group. The at-risk group contained 17 children, aged between 18 and 27 months, and the control group consisted of 12 children with an age-range of 18 to 26 months. The data of four at-risk and two control children were excluded because of hearing problems or illnesses that could lead to neurological or hearing problems. The mean age of the remaining 13 at-risk children was 21 months, and the mean age of the remaining 10 children in the control group was 22 months. The difference in age was not significant ($t = .640$, $p = .529$).

In order to participate it was required that the children had Dutch as native language and did not have developmental disorders, speech/language disorders, or hearing problems. Bilingual children were also excluded. To be included in the at-risk group the children had to have at least one parent with dyslexia. When dyslexia was not formally diagnosed, two screening tests were conducted to confirm the reading problems: the 'Een Minuut Test' (Brus & Voeten, 1999), in which the parent had to read as many isolated words as possible in one minute; and a similar test called 'De Klepel' (Van den Bos et al. 1994), in which as many phonotactically legal nonsense words as possible had to be read during two minutes. If the parents scored below the 10^{th} percentile on one of these tests, or the average of both reading tests was below the 25^{th} percentile, the condition to be included in the at-risk group was met. The children in the control group did not have a familial history of dyslexia or reading problems. To be sure that the children had a typical development, the Dutch version of the Bayley Scales of Infant Development (BSID-II-NL, Van der Meulen et al., 2002) was conducted. In both groups all children scored in the normal range, no significant differences were found between the groups ($t = 1.077$, $p = .295$). The mean scores for both groups can be found in table 1.

Data from another 18 at-risk and 12 control children (aged between 18 and 20 months), who participated in the experiment conducted by Van der Ven (2004), were added to create a larger sample. From these data three at-risk children were excluded, because they did not meet our criteria to be included in the at-risk group.

This resulted in a final sample of 28 at-risk children and 22 control children with a mean age of 20 months for both groups. The difference in age was not significant ($t = .736$, $p = .465$). The distribution of number, age and gender of the participants is presented in table 1.

	Present study					Van der Ven (2004)				Total			
	N	boys	girls	age	BSID	N	boys	girls	age	N	boys	girls	age
At-risk	13	9	4	21.87	101.91	15	10	5	18.74	28	19	9	20.19
Control	10	5	5	22.70	108.40	12	6	6	19.18	22	11	11	20.78
Total	23	14	9	22.23	105.00	27	16	11	18.93	50	30	20	20.45

Table 1: Overview of number, gender, age and BSID score of subjects participating in the study

<u>Measures</u>

In order to find out whether the at-risk children were able to discriminate between grammatical and distorted dependencies the Preferential Listening Procedure was used. A language test, inventories, questions about general development and observations were used to search for differences between the two groups in language, motor skills and concentration.

<u>Preferential Listening</u>

- Design

The Preferential Listening Procedure was used, as described in Kemler Nelson et al. (1995). The aim of this procedure is to determine whether children prefer one kind of stimulus to another. The preferences are measured exposing a child to one type of stimulus in half of the test trials and to the other type of stimulus on the remainder. The auditory stimuli are presented in a random order and randomly from locations that require the child to turn its head to the left or right. The index of preference is the difference in the average length of the infant's looking time to the two different kinds of stimuli over the test-trial series. In this method it is assumed that looking time equals listening time. This procedure is appropriate for young children because it does not require children to point, answer questions or act out instructions. It takes advantage of the fact that children tend to orient visually to an attended sound source and that they learn to maintain a response when motivating stimulation is contingent on their behaviour.

In the present study two preferential listening experiments were conducted. These experiments were replications of previous studies. The replication of the experiment by Wilsenach and Wijnen (2004) will be referred to as the experiment with an intervening adverb and the replication of the experiment by Van der Ven (2004) will be called the experiment without adverb.

- Stimuli

Experiment with intervening adverb

The same stimulus material as in the experiment of Wilsenach and Wijnen (2004) was used, which consisted of 16 passages: eight grammatical and eight matching ungrammatical passages. There were four training trials and 12 test trials. All passages were eight sentences long and had a duration of 20.9 seconds. In the grammatical passages the sentences contained the temporal auxiliary 'heeft' (have) and the past participle form of the main verb, which is usually formed by adding the prefix 'ge-' and the suffix '-d/-t' to the main verb. The auxiliary 'heeft' and the past participle prefix 'ge-' form a grammatical morphosyntactic dependency in Dutch. In the ungrammatical passages the auxiliary 'heeft' was replaced by the auxiliary 'kan' (can), which led to a distorted dependency. The two dependent morphemes were separated by a 2-syllable adverb. The sentences can be found in appendix 1. For more details about the stimulus material we refer to Wilsenach and Wijnen (2004) and Wilsenach (2006).

Experiment without adverb
The stimuli used for the experiment without adverb were taken from the experiment by Van der Ven (2004). She adapted the stimulus material of the experiment with intervening adverb by removing the intervening adverb and by adding two sentences to keep the passages as long as in the experiment with intervening adverb. The total length of each passage was approximately 24.5 seconds. The sentences are added as appendix 2. For more details see Van der Ven (2004).

- Procedure

The experiment was conducted in a three sided test-booth, which was located in a soundproof and dimly lit room. The test booth is shown in figure 1.

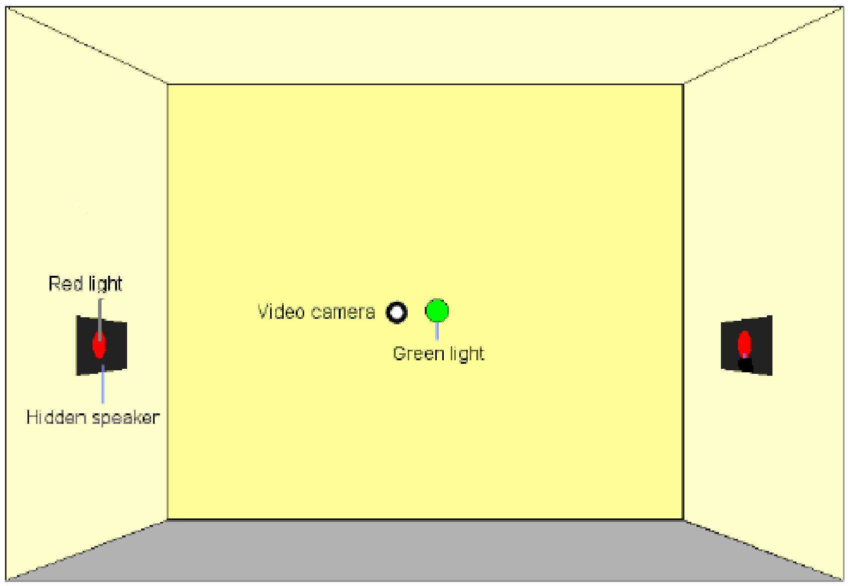

Figure 1: Test booth

A green light consisting of several LEDs was attached to the front panel. A similar red light was attached to each side panel of the test booth. On both sides a speaker was hidden behind the side panels. A video camera made it possible to record the head movements of the child during the experiment. The lens of the camera was situated in front of the child next to the green light. The recording was directly projected on a television screen that was located outside the soundproof room. All other equipment necessary for performing the experiment (computer, amplifier, CD-player and a two-button response box) was also located outside the soundproof room.

During the experiment the child was sitting on its parent's lap in the middle of the test-booth facing the green light. The parent was wearing headphones with masking music. This was done to prevent the parent from influencing the behaviour of his or her child. The parent was instructed to point to the green light if necessary, but not to the red lights. At the beginning of each trial the attention of the child was drawn to the middle by flashing the green light. Whenever the child looked at the green light, a button on the response box was pressed which started the flashing of a red light at one of the sides. If the child turned its head to the flashing red light, again a button was pressed which initiated an auditory stimulus and started a timer. The experimenter indicated by pressing buttons if the child was looking at or looking away from the light. At the same time the timer stopped counting when the child looked away and continued again when the child looked back within two seconds. The auditory stimulus

continued to play either until the end of the passage was reached or until the child moved its eyes or head away from the light for more than two seconds. The experiment was interrupted if the child refused to cooperate any longer. If the first experiment was interrupted, the second experiment was presented after a short break.
The test trials were presented in a pseudorandom order with the restriction that no more than two successive trials of the same type were allowed. The position of the stimuli was also pseudorandom; no more than two successive trials came from the same side of the test booth. An Intel Celeron computer equipped with custom-made software and hardware interfaces controlled the presentation of the stimuli and recorded the experimenter's scoring of the child's responses.

- Data analysis

The computer created a file in which looking times for each passage were stored. The looking times of each passage were checked by two experimenters using the videotaped sessions. They were checked for timing of the button presses. If a button press did not correspond with the looking behaviour of the child the passage was either removed or adjusted. The adjustments were made by playing the video recording and recording the looking time once more by using a stopwatch. This was done by two experimenters. The same procedure was used as described above: the time started running when the auditory stimulus started to play and the time was stopped and started again according to the child's looking behaviour. The mean of the new looking times measured by the two experimenters with the stopwatch was used for analysis.

In addition, trials were removed because of crying, babbling, refusing to sit still, parental interference during a trial, and experimental or technical errors. When a grammatical passage was removed, the matching ungrammatical passage was removed as well and vice versa, because when a grammatical passage is compared to a non-matched ungrammatical passage it is possible that interest in content of the passages is measured instead of preference for grammaticality. Whenever less than three grammatical and three matching ungrammatical passages remained, the child was excluded for analysis.
The listening times were checked for ceiling effects. A ceiling effect was assumed when a child listened to the entire trial in at least six trials without turning its head away. No ceiling effects were found.
Passages with listening times shorter than one sentence were not taken into account for analysis[1], because it was assumed that in this case a child was not able to hear if the passage was grammatical or ungrammatical. In the experiment with intervening adverb listening times shorter than 2113 milliseconds were removed, whereas in the experiment without adverb listening times shorter than 1550 milliseconds were removed. These interruption times were calculated by dividing the total duration of the passages minus the pauses between the sentences by the number of sentences in the passage. For each group the mean looking time to the grammatical and ungrammatical passages was calculated.

<u>*Language*</u>

To measure receptive language development, the Reynell Test voor Taalbegrip (Van Eldik et al. 1995) was used. This test is suited (i.e. validated and normed) for children aged between 1y2m and 6y3m. In this test children have to use toys to respond to auditory questions and act out auditory instructions. Furthermore, an inventory for receptive language was filled in by the parents: Taalbegripslijst Dreumesen (Schlichting & Lutje Spelberg, in press). This

[1] The data including the shorter listening times were also analyzed. However, these data did not reveal different results than the results described below and are therefore not taken into consideration.

inventory contains short sentences and words and is suited for children aged between 15 and 25 months. Parents had to mark which sentences and words their child already understood.

Productive language development was assessed using the Lexilijst Nederlands (Schlichting & Lutje Spelberg, 2002). This is a standardized inventory of the productive vocabulary for children aged between 17 and 25 months. It contains frequently used words and a few short sentences. The parents had to mark the words and sentences their child produced spontaneously.

In addition, questions concerning the general development were asked using a questionnaire. The questions concerned birth, birth rank, education of parents, familial background of dyslexia, speech/language development, hearing, and motor development. The age at which the child produced the first word as reported by the parents was used for analysis.

Motor skills

The development of motor skills was also assessed by means of the above-mentioned questionnaire. Information about the age at which the child started with its first steps, progress of motor development, and whether the child had a normal crawling period was used. The information about progress of motor development was gathered by asking the parents at what age their child reached the motor milestones such as sitting, standing, crawling and walking and whether they judged their child's progress in motor development as slow, normal or fast. Based on this information the general motor development was categorized as either slow or normal/fast. Furthermore, a child was categorized as having a normal crawling period if the parents reported that their child had been crawling on hands and knees before walking. If they reported that their child used belly or buttocks to move around or walked before crawling or did not crawl at all, crawling was categorized as deviant.

In addition, mouth behaviour was observed during the experiment. It was observed whether the child showed open mouth behaviour during the preferential listening experiments, playing and the language and developmental tests. In addition, the parents were asked if the child had frequently open mouth behaviour. When a child had an open mouth more than half of the time and the parents reported open mouth behaviour, mouth behaviour was categorized as deviant.

Concentration

Also, concentration of the child during the experiment was taken into account. Concentration during the listening experiments, the language test, the developmental test and during playing was observed for this purpose. In order to be categorized as having normal concentration, the child had to listen to at least three matching passages of the first listening experiment and complete the part of the language and developmental test which it had to be able to complete according to his or her age. Furthermore, it was observed if the child paid attention to what was being said to her/him during the tests. On the basis of this information the concentration of a child was categorized as either normal or poor.

To ensure that test conditions were maximally similar across children, a standard order was used for the assessment. First, the preferential listening experiments were conducted. Generally, after entering the lab the children were still a little confused about the new situation and therefore more willing to cooperate in the listening experiments, in which it was necessary to be quiet and sit still. In addition, they were not yet distracted by the toys in the room. The experiment without adverb was run first. This was the most important one, because this experiment needed to be replicated in order to answer the main research question. If necessary a break was inserted between the two listening experiments. However, no break was preferred because the experience taught us that children did not want to enter the test booth again after discovering the toys. Secondly, the questions concerning general development were asked and the two inventories were discussed. During this conversation the child had the opportunity to play and get used to the room and the experimenters. After the conversation the language and developmental tests were administered. Finally, reading tests were conducted with the parent of the at-risk child, if necessary.

4.4. Results

In this part the results of the analysis of differences between the groups in preferential listening, language skills, motor skills and concentration will be discussed. Correlations between all these variables and preference for grammatical stimuli and three multiple regression models predicting preference for grammatical stimuli will also be summarized.

Differences in preferential listening, language skills, motor skills and concentration
For analysis of group differences concerning the preferential listening experiments, the data of Van der Ven (2004) were added. She did not dispose of data on language, motor skills and concentration. For analysis of these variables, the data of the sample of the present study were used only.

- Preferential Listening

Experiment with intervening adverb
This experiment was conducted after the experiment without adverb. Fewer children finished this experiment, because of the relatively short concentration span of young children. The remaining sample for analysis consisted of 25 at-risk children and 12 control children.

The mean listening time of the at-risk group to the grammatical passages was 8.18 seconds (SD 3.78), whereas the mean listening time to the ungrammatical passages was 7.76 seconds (SD 3.76). The paired difference between the mean listening times was 0.51 seconds. Though the children listened longer to the grammatical passages, this difference was not significant ($t = .528$, $p = .602$). 52% of the at-risk children listened longer to the grammatical passages.
The mean listening time of the control group to the grammatical passages was 9.31 seconds (SD 4.04) and the mean listening time to the ungrammatical passages was 9.29 seconds (SD 4.91). The paired difference between these mean listening times was 0.02 seconds. This difference was not significant ($t = .016$, $p = .988$). 58% of the children in the control group listened longer to the grammatical passages.
The results of the at-risk group and the control group are presented in figure 2. The control group listened approximately equally long to both grammatical and ungrammatical passages, whereas the at-risk group listened slightly longer to the grammatical passages.

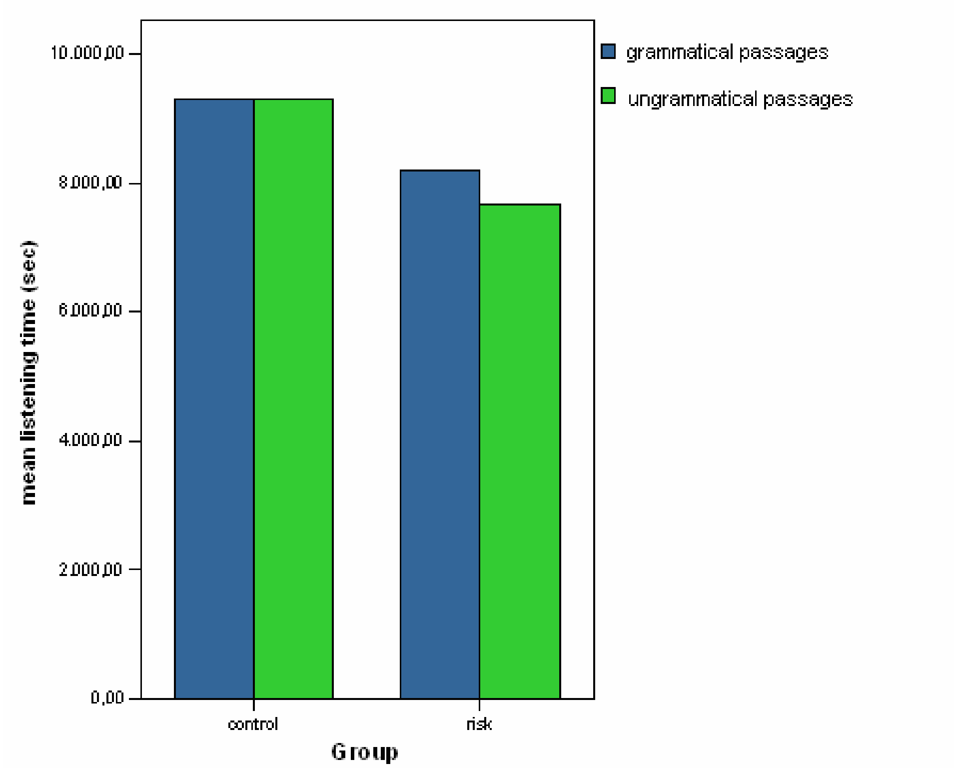

Figure 2: Mean listening times for both groups to grammatical and ungrammatical passages in the experiment with intervening adverb

Experiment without adverb

The data of one at-risk child and one control child were not analysed, because not enough matched passages were left. The remaining sample for analysis consisted of 27 at-risk children and 21 control children.

The mean listening time of the at-risk group to the grammatical passages was 10.19 seconds (SD 3.91), whereas the mean listening time to the ungrammatical passages was 9.16 seconds (SD 4.61). The paired difference between the mean listening times was 1.02 seconds. So the children listened longer to the grammatical passages, however, this difference was not significant ($t = 1.04$, $p = .307$). 59% of the at-risk children listened longer to the grammatical passages.

The mean listening time of the control group to the grammatical passages was 10.56 seconds (SD 4.22) and the mean listening time to the ungrammatical passages was 9.68 seconds (SD 5.41). The paired difference between these mean listening times was 0.89 seconds. So the control children listened longer to the grammatical passages, but this difference was not significant ($t = .626$, $p = .538$). 48% of the children in the control group listened longer to the grammatical passages.

The results of the at-risk group and the control group are presented in figure 3. In this figure can be seen that both groups showed the same pattern; they both listened longer to grammatical passages.

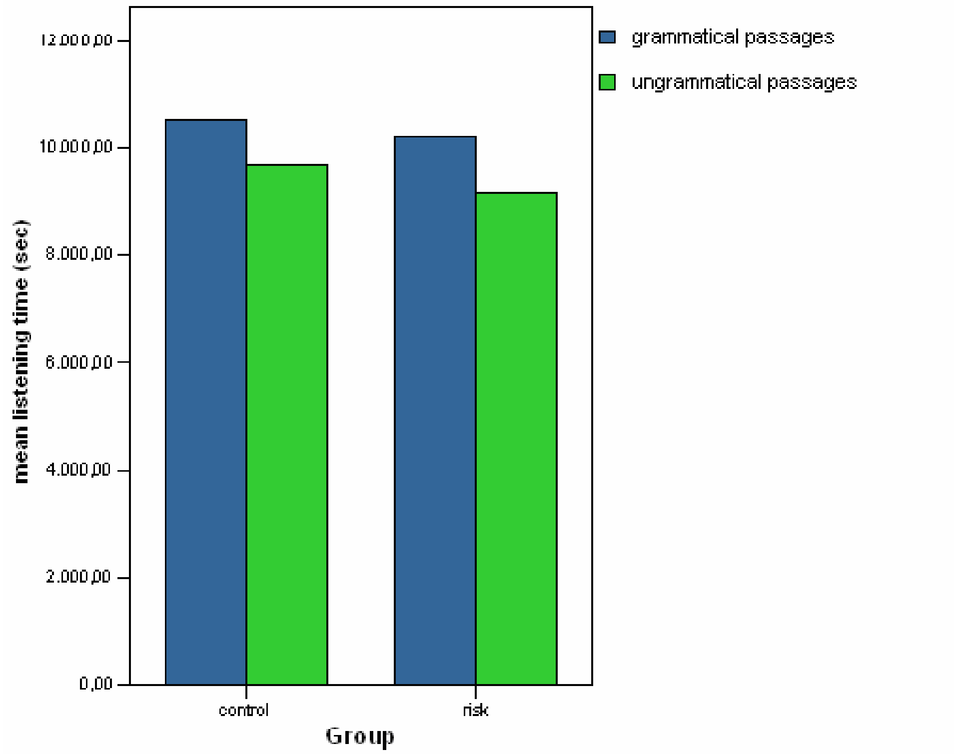

Figure 3: Mean listening times for both groups to grammatical and ungrammatical passages in the experiment without adverb

In addition to analysing the listening preference by using mean listening times, differences in raw listening times between the at-risk group and the control group were analysed. This was based on the idea that the at-risk children could have shorter listening times than the controls. It could be that at-risk children listen shorter overall because of a shorter concentration span. This idea was verified by performing independent samples t-tests for grammatical listening times, ungrammatical listening times and total listening times for the experiment with intervening adverb and the experiment without adverb. No significant differences between the groups were found in raw listening times. So it can not be concluded that the at-risk children listened longer or shorter overall.

- Language

The data from 11 at-risk children and 10 control children were available for analysis of the Reynell Test voor Taalbegrip. The mean receptive language quotient for the at-risk group was 115.64 (SD 18.93) and for the control group 119.20 (SD 11.80). The results showed that the at-risk group scored slightly lower than the control group, however, this difference was not significant: $t = .511$, $p = .615$.

The receptive language inventory was completed by the parents of 12 at-risk children and 9 control children. Raw scores were used for analysis, because the standards were not yet available. It is allowed to use raw scores, because there is no significant age difference between the two groups. The mean score of the at-risk group was 118.75 (SD 60.58) and the mean score of the control group was 145.67 (SD 45.85). Again the at-risk group showed lower receptive language scores, but this difference was not significant: $t = 1.113$, $p = .280$. It must be noted though, that the standard deviations were very high.

The Lexilijst was returned by the parents of 13 at-risk children and 9 control children. The mean Lexiquotient for the at-risk group was 97.38 (SD 15.21) and for the control group

106.11 (SD 15.09). On this productive vocabulary inventory, the at-risk group showed a lower quotient, but again this difference was not significant: t = 1.327, p = .199.

The age of first word production as reported by the parents was analysed for 13 at-risk children and 9 control children. The mean age of the first word of the at-risk group was 11.39 months (SD 2.54), whereas the mean age of the first word of the control group was 11.11 months (SD 2.93). This difference was not significant: t = -.233, p = .818. Figure 4 shows the results of both groups on the different language measures.

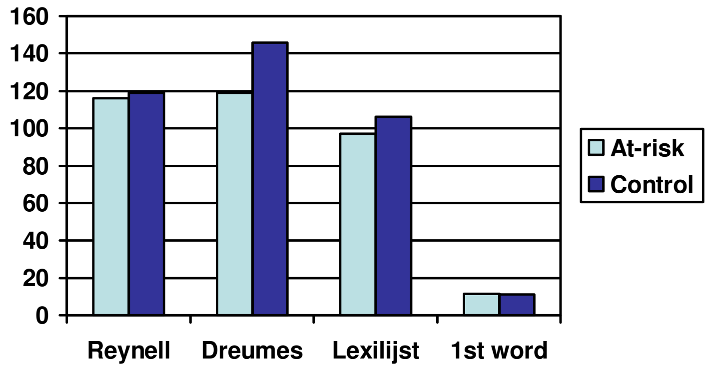

Figure 4: Scores on the different language measures. The bars Reynell and Lexilijst represent quotients, the bar Dreumes represents raw score, the bar first word represents the age in months

- Motor skills

The data about the age of the first steps from 11 children at risk for dyslexia and 10 control children were analysed using an independent-samples t-test. The mean age of the first steps of the at-risk group was 14.32 months (SD 1.99) and of the control group 13.90 months (SD 1.71). The children in the at-risk group started walking slightly later, but the difference was not significant: t = -.513, p = .614.

Differences in progress of motor development, in crawling, and in mouth behaviour were analysed by Fisher's exact tests. It was analysed whether group factor could lead to differences in these variables. It could be that the group to which a child belongs, at-risk or control, defines whether motor development is fast or slow and whether crawling and mouth behaviour are deviant or not. The data from 13 at-risk children and 10 control children were used. No associations were found between group and progress in motor development (p = .618, two-tailed), group and presence of a crawling period (p = .660, two-tailed), and group and mouth behaviour (p = .100, two-tailed), which means that there are no significant differences in these three variables between the two groups. However, a trend was found for an association between group and mouth behaviour, which implies that more children in the control group showed deviant mouth behaviour. The percentages of the children who showed delayed motor development, a deviant crawling period and/or deviant mouth behaviour are shown in table 2.

	Motor development	Crawling	Mouth behaviour
At-risk	15%	31%	58%
Control	30%	20%	60%

Table 2: Percentages of the children who showed delayed motor development, , a deviant crawling period and/or open mouth behaviour

- Concentration

Information about concentration was gathered for 13 at-risk children and 10 control children. The differences were analysed by Fisher's exact tests. It was analysed whether group (risk vs. control) had influence on concentration span. No associations were found between group and concentration: p = 1.00, two-tailed. In the at-risk group 38% of the children had poor concentration. A similar percentage of 40% was found in the control group.

<u>Correlations</u>

Pearson's correlation coefficients, Spearman's correlation coefficients and eta coefficients were computed to investigate the associations between preference for grammaticality and all other variables separately (interval as well as nominal). The preference for grammaticality was calculated by subtracting the mean listening time to ungrammatical passages from the mean listening time to grammatical passages.

The interval variables were tested for normality using the Kolmogorov-Smirnov test. All interval variables had a normal distribution except for age of first steps. Transformation did not result in normal distribution, so for this variable Spearman's correlation coefficient was used.

- Preferential listening and language and non-language measures

Correlation coefficients between preference for grammatical stimuli as determined in both preferential listening experiments (with intervening adverb and without adverb) and age, general development (BSID), several language measures (Reynell, Dreumesen, Lexilijst, first word) and first steps are summarized in table 3.

There were no significant correlations between preference for grammaticality and any of the other variables, except for a weak significant correlation between age and preference for grammaticality as measured in the experiment without adverb in the at-risk group (r = -.382, p = .049). A trend for a similar correlation was found in the experiment with intervening adverb for the at-risk group (r = .350, p = .087).

Furthermore, in the experiment with intervening adverb a trend was found in the at-risk group for a moderate correlation between the age at which the first word was produced and preference for grammaticality (r = -.545, p = .083), whereas in the control group a trend was found for a strong correlation between score on the Reynell and preference for grammaticality (r = .852, p = .067).

Group	Experiment	Age[a] (months)	BSID[a] (OI)	Reynell[a] (TBQ)	Dreumesen[a] (raw score)	Lexilijst[a] (LQ)	First word[a] (age in months)	first steps[b] (age in months)
At-risk	With intervening adverb	.350 (.087)	-.045 (.901)	.045 (.903)	.336 (.343)	.180 (.597)	-.545 (.083)	.068 (.862)
At-risk	Without adverb	-.382* (.049)	-.249 (.461)	-.368 (.266)	-.273 (.416)	-.016 (.962)	-.200 (.532)	.166 (.647)
Control	With intervening adverb	.140 (.663)	.513 (.377)	.852 (.067)	.570 (.430)	.608 (.392)	-.273 (.727)	-.289 (.638)
Control	Without adverb	.144 (.534)	-.262 (.464)	-.273 (.445)	-.247 (.521)	-.327 (.391)	-.176 (.651)	.110 (.762)

Table 3: Pearson's correlation coefficients[a] or Spearman's correlation coefficients[b] (significance two-tailed in brackets) between preference for grammaticality and all interval variables. *correlation is significant.

▪ Preferential listening and motor skills and concentration

Associations between preference for grammatical stimuli as determined in both preferential listening experiments (with intervening adverb and without adverb) and the nominal variables progress of motor development, crawling, mouth behaviour and concentration are summarized in table 4. Pearson's or Spearman's correlation coefficients could not be used, as these coefficients are designed for the analysis of relations between interval or ratio variables only. The eta statistic, which is designed for the case when one of the measures is nominal and the other is interval, was therefore used. The eta-squared coefficient indicates how well one variable can be predicted from another even with nonlinear relationships and can be interpreted in a manner similar to the squared Pearson's correlation coefficient, r^2. If it is significant, then the two variables are not independent.

There were no significant associations between preference for grammaticality and any of the other variables, except for a moderate association between grammatical preference and mouth behaviour for the at-risk group in the experiment without adverb; 42.1% of the variability in preference for grammaticality was explained by mouth behaviour.

Group	Experiment	Progress of motor development	Crawling	Mouth behaviour	concentration
At-risk	With intervening adverb	.005 (.834)	.062 (.459)	.024 (.699)	.006 (.820)
At-risk	Without adverb	.025 (.621)	.005 (.823)	.421* (.031)	.001 (.936)
Control	With intervening adverb	.034 (.766)	.034 (.766)	.256 (.384)	.001 (1.000)
Control	Without adverb	.004 (.865)	.070 (.459)	.075 (.443)	.165 (1.000)

Table 4: Eta squared coefficients (significance two-tailed in brackets) between preference for grammaticality and all nominal variables. *association is significant.

<u>Multiple regression</u>

Stepwise multiple regression has been performed to investigate the influence of age, general development, language and motor variables (interval) on preference for grammaticality, measured in the preferential listening experiments. Three models were created; a model with all language variables, a model with non-language variables, and a model in which both the language and non-language variables were represented. The preference for grammaticality was calculated by subtracting the mean listening time to ungrammatical passages from the mean listening time to grammatical passages.

▪ Preferential listening and language variables

A model was created in which the receptive language quotient, the scores on the receptive and the productive language inventories, and the age at which the first word was produced were represented. This model was created to identify possible relationships between preference for grammaticality and language development.

Experiment with intervening adverb

In the at-risk group the model with all language variables explained 71.9% of the variability. First the productive language variables were removed from the model. The age at which the first word is produced contributes the least to the explained variability (3.3%), whereas the score on the receptive language inventory (Dreumes) explains most of the variability within this model (42.9%). In the control group, too few data of subjects remained to perform multiple regression. The model summary for the at-risk group is shown in table 5.

Model (at-risk group)	R^2
1. Including first words, TBQ, LQ and Dreumes	.719
2. Including TBQ, LQ and Dreumes	.686
3. Including TBQ and Dreumes	.543
4. Including Dreumes	.429

Table 5: Model summary of the regression model including all language variables predicting the preference for grammaticality in the experiment with intervening adverb (TBQ = score on Reynell Test voor Taalbegrip, LQ = score on Lexilijst, Dreumes = score on inventory Dreumesen, first word = age of first word production).

Experiment without adverb

In the at-risk group the model with all language variables explained 40.7% of the variability. The age at which the first word is produced adds the least to the explained variability (1.5%), whereas the receptive language quotient (TBQ) explains most of the variability within this model (16.5%).

In the control group the total model explained 31.1% of the variability in preference for grammaticality. The score on the receptive language inventory (Dreumes) adds nothing to the explained variability and the TBQ just 1.9%. The score on the productive language inventory (LQ) explains the most, but still not much (10.7%). The model summary for both groups is presented in table 6.

Group	Model	R^2
At-risk	1. Including first words, TBQ, LQ and Dreumes	.407
	2. Including TBQ, LQ and Dreumes	.392
	3. Including TBQ and LQ	.306
	4. Including TBQ	.165
Control	1. Including first words, TBQ, LQ and Dreumes	.311
	2. Including first words, TBQ and LQ	.311
	3. Including first words and LQ	.292
	4. Including LQ	.107

Table 6: Model summary of the regression model including all language variables predicting the preference for grammaticality in the experiment without adverb (see table 5 for abbreviations).

- Preferential listening and non-language variables

A model was created in which age, age of first steps and general development, as measured by the Bayley Scales of Infant Development (BSID), are represented. This model was created to identify possible relationships between preference for grammaticality and the non-language variables age, age of first steps and general development.

Experiment with intervening adverb

In the at-risk group the model with all non-language variables explained 56.5% of the variability. The age at which the first steps were made adds the least to the explained variability (0.7%), whereas the age in months explains most of the variability within this model (47.9%). In the control group too few data of subjects remained to perform multiple regression. The model summary for the at-risk group can be seen in table 7.

Model (at-risk group)	R^2
1. Including first steps, age in months and OI	.565
2. Including age in months and OI	.558
3. Including age in months	.479

Table 7: Model summary of the regression model including all non-language variables predicting the preference for grammaticality in the experiment with intervening adverb (first steps = age of first steps, age in months = age of the child at the time of the experiment, OI = score on the developmental test BSID).

Experiment without adverb

In the at-risk group the model with all non-language variables explained 22.9% of the variability. The developmental index (OI) adds the least to the explained variability (1.0%), whereas age in months explains most of the variability within this model (14.0%).

In the control group the total model explained 9.5% of the variability in preference for grammaticality. The age in months adds nothing to the explained variability, whereas the developmental index (OI) explains the most, but still not much (6.9%). In table 8 the summary of the model is presented for both groups.

Group	Model	R^2
At-risk	1. Including First steps, age in months and OI	.229
	2. Including First steps and age in months	.219
	3. Including age in months	.140
Control	1. Including First steps, OI and age in months	.095
	2. Including First steps and OI	.095
	3. Including OI	.069

Table 8: Model summary of the regression model including all non-language variables predicting the preference for grammaticality in the experiment without adverb (see table 7 for abbreviations).

- Preferential listening and language and non-language variables

A model was created in which both the language and non-language variables, used in the models described above, were represented. This model was created to identify possible relationships between preference for grammaticality and the language and non-language variables.

Experiment with intervening adverb

In the at-risk group the model with all variables explained 99.6% of the variability. Almost all of the variability in preference for grammaticality is thus explained by this model. The score on the receptive language test (TBQ) added the least to the explained variability (1.5%). Most variability is explained by the developmental index (OI), age in months, and score on productive language inventory (LQ) together (87.1%). In the control group too few data of subjects remained to perform multiple regression. The model summary for the at-risk group can be seen in table 9.

Model (at-risk group)	R^2
1. Including first steps, Dreumes, first words, OI, TBQ, LQ and age in months	.996
2. Including first steps, Dreumes, first words, OI, LQ and age in months	.981
3. Including first steps, Dreumes, OI, LQ and age in months	.951
4. Including first steps, OI, LQ and age in months	.904
5. Including OI, LQ and age in months	.871

Table 9: Model summary of the regression model including all interval variables predicting the preference for grammaticality in the experiment with intervening adverb (see table 5, 7 for abbreviations).

Experiment without adverb

In the at-risk group the model with all variables explained 59.8% of the variability. The age at which the first steps are made adds the least to the explained variability (0.7%), whereas the receptive language inventory (Dreumes) explains most of the variability within this model (27.2%).

In the control group the total model explained 98.5% of the variability in preference for grammaticality, so almost all of the variability is explained by this model. The age at which the first steps are made and the receptive language quotient (TBQ) do not add much to the explained variability (0.2%). The scores on the receptive and productive language inventory (Dreumes and LQ), age at which the first words were said, the developmental index (OI), and age explain together 98.3% of the variability. The summary of the model is shown in table 10.

Group	Model	R^2
At-risk	1. Including first steps, Dreumes, TBQ, first words, age in months, OI and LQ	.598
	2. Including Dreumes, TBQ, first words, age in months, OI and LQ	.591
	3. Including Dreumes, TBQ, first words, OI and LQ	.536
	4. Including Dreumes, TBQ, OI and LQ	.504
	5. Including Dreumes, TBQ and LQ	.467
	6. Including Dreumes and LQ	.364
	7. Including LQ	.092
Control	1. Including first steps, LQ, Dreumes, first words, TBQ, OI and age in months	.985
	2. Including LQ, Dreumes, first words, TBQ, OI and age in months	.984
	3. Including LQ, Dreumes, first words, OI and age in months	.983

Table 10: Model summary of the regression model including all interval variables (see table 5, 7 for abbreviations) predicting the preference for grammaticality in the experiment without adverb

4.5. Discussion

The main aim of the present study was to find the cause of the previous findings by Wilsenach and Wijnen (2004) that 19-month-old at-risk children in contrast to control children were not able to discriminate between grammatical and distorted dependencies in passages containing a 2-syllable adverb between the auxiliary ‘heeft’ (has) and the past participle. Two possible explanations were proposed: the at-risk children either do not have the knowledge yet to recognize the investigated morphosyntactic dependency or they suffer from a processing deficit, due to which they are unable to discriminate between grammatical and distorted versions. To investigate which explanation is correct, the experiment without adverb was done. In this experiment the intervening adverb was removed to reduce processing load. If at-risk children suffer from a processing deficit, they should be able to discriminate between grammatical and distorted dependencies now. When no preference for grammaticality is found again, this could be seen as support for the explanation that at-risk children are not sensitive to this morphosyntactic dependency at this age. It turned out that in this experiment, both groups showed longer listening times to the grammatical passages than to the ungrammatical passages (at-risk: 10.19 vs. 9.16 seconds; control: 10.56 vs. 9.68 seconds), but these differences were not statistically reliable. Thus the at-risk group performed similar to the control group. A clear conclusion regarding the most plausible explanation cannot be made due to the remarkable finding that the control group did not show a preference either. In order to find out if our subjects showed the same behaviour as the subjects of Wilsenach en Wijnen (2004), the experiment with intervening adverb was replicated.

Wilsenach and Wijnen (2004) found that the control group listened significantly longer to the grammatical than to the ungrammatical passages (9.61 vs. 8.21 seconds). This was interpreted as a preference for correct grammatical dependencies. In contrast, the at-risk group did not show a preference for grammaticality. These children listened longer to the ungrammatical passages (grammatical: 8.00, ungrammatical: 8.69 seconds), but this difference was not significant. In the present study the findings of Wilsenach and Wijnen were replicated for the at-risk group; no preference for grammaticality was found. On the other hand, the findings of the study by Wilsenach and Wijnen could not be replicated for the control group in the present study. The control children did not show a preference for grammaticality, the listening times to grammatical and ungrammatical passages were approximately equal (9.31 vs. 9.29 seconds). Thus, it turns out that the sample in the present study does not show the same behaviour as the sample in the previous study by Wilsenach and Wijnen. On the basis of the results of the present study, there is no reason to assume a difference in sensitivity to the grammatical dependency of an auxiliary and a past participle between the two groups in either experiment. In both experiments the at-risk as well as the control children performed similarly by showing no clear preference for either grammatical or ungrammatical passages. Consequently, an answer to the main research question has to be deferred, as it cannot be answered on the basis of these results.

The remarkable fact that the findings of Wilsenach and Wijnen (2004) were not replicated could be due to a difference in sample size; the sample for the experiment with intervening adverb in the present study consisted of 25 at-risk children and 12 control children, whereas Wilsenach and Wijnen had a sample of 53 at-risk children and 31 control children. If we assume that the results of the control group of the replicated experiment with intervening adverb cannot be taken into account because of the small sample size, the fact that the control group, consisting of 21 children, does not show a preference for grammaticality in the experiment without adverb either is still strange. However, it could be that both groups are still too small to find differences. Although this seems not plausible, as the samples in the different experiments of Santelmann & Jusczyk (1998) consisted of 24 children.

Another important fact is that in the present study the experiment with intervening adverb was conducted after the experiment without adverb. This could have had an effect on concentration; the children may have become tired and/or bored, which could have affected the measurements of preference for grammaticality. It could be that the children did not react consistently due to tiredness and/or boredom. This is supported by the fact that fewer children finished the second experiment. More children were unquiet during this experiment; they started talking, asking for the end of the experiment, crying and/or wobbling. Furthermore, the passages in both experiments were highly similar. If a child continued to listen to all passages during both experiments, it had to listen to four highly similar passages, which may be boring for the child. Because of this, comparing the results of this experiment to the results of Wilsenach and Wijnen (2004) is not totally legitimate.

Another possible explanation is that the distribution of gender in the control group was different between the two samples. Differences between the samples in gender distribution could have influenced the results, as it is commonly known that boys are slower in language development. It could be that girls are better in discriminating between the grammatical and ungrammatical dependencies because of their faster language development. Due to the small sample sizes it was not possible to analyze the data separately for girls and boys. However, something can be said about the proportion of girls and boys. In the present experiment 6 out of 12 (50%) participants were female in the control group, whereas in the experiment by Wilsenach and Wijnen the control group consisted of 19 boys and 12 girls (39% girls). This explanation seems not to be right since the percentage of girls is higher in the present control group as compared to the study of Wilsenach and Wijnen and still no preference for grammaticality is found.

Furthermore, in the present study older children were included which makes the comparison not totally valid. In the present study children with an age range of 18 to 27 months took part, whereas in the previous study the age range was between 18 and 22 months. It is possible that the older children show a preference for new constructions, instead of familiar constructions. A number of factors influence children's direction of preference. In general, novelty preferences are associated with easy learning tasks, and familiarity preferences are associated with more difficult tasks (Saffran & Thiessen, 2003). It could be that the older children showed a novelty preference by listening longer to the ungrammatical passages, because the task is easier for them, whereas the younger children showed a familiarity preference, as the task is more difficult for them. This could have neutralized the differences in listening times in the present study. This is supported by the fact that the variability in preference-for-grammaticality score in both groups was quite large.

In addition to sensitivity to morphosyntactic dependencies, differences in language and motor development and concentration between the two groups were investigated. No significant differences were found; from this can be concluded that the groups did not differ in these domains. However, the percentage of children who did not have a crawling period was higher in the at-risk group. By contrast, more children in the control group were reported to be slow in motor development.

The failure in finding group differences on the language measures is in contrast to previous findings of vocabulary deficits in 17-month-old at-risk children (Koster et al., 2005) and of a significant proportion of late talkers in the at-risk group (Snowling et al., 2003; Koster et al., 2005). However, some studies did also not find vocabulary deficits before the age of 3 years (Lyytinen, Poikkeus et al., 2001, 2004; Lyytinen & Lyytinen, 2004). Furthermore, although the differences were not significant, the at-risk group scored worse than the control group on all language measures. This is interesting, as language deficits are most consistently reported in older at-risk children (chapter 3); it could be that the worse scores may be seen as a beginning delay in language development.

Another explanation however could be the possibility that the present at-risk sample contains more children who will not develop dyslexia. The risk of developing dyslexia in at-risk children is estimated at 32 to 68% (see chapter 1). Conceivably, the majority of the children in the sample of the present study become typical readers. This could also explain the fact that the at-risk group and the control group showed the same pattern in the listening experiments. The fact that no significant proportion of late talkers was found in the at-risk group, in contrast to other studies provides some support for this suggestion. The fact that none of the at-risk children had a weak score on the standardized language test (Reynell) also supports this suggestion; they all scored within the normal range. In this case the slightly poorer scores of the at-risk children on each of the language measures could be due to the continuity of dyslexia (see chapter 3). It would therefore be interesting to take the incidence of dyslexia in both groups into account. This makes it also possible to split the at-risk group up into a later dyslexic and a later non-dyslexic group which may reveal different results.

Correlations and multiple regressions between preference for grammaticality and measures for language, motor skills and concentration were computed. It turned out that none of the variables significantly correlated with performance in the preferential listening experiments, except for a weak correlation between age and preference for grammaticality and a moderate association between mouth behaviour and preference for grammaticality in the at-risk group in the experiment without adverb. Interestingly, Wilsenach (2006) repeated the experiment with intervening adverb with a slightly older sample of at-risk children aged around 25 months. She did not find evidence for a change in perceptual behaviour. The weak correlation found in the present experiment between age and preference for grammaticality in the at-risk group seems to contradict this. However, this weak correlation was found in the experiment without adverb. Nevertheless, in the experiment with intervening adverb a trend was noted for this correlation ($p = .087$). In the multiple regression analysis with non-language variables was also found that age explained most variability in preference for grammaticality in the at-risk group in both experiments. This points to a change in preference for grammaticality with increasing age. However, the two correlations are reversed in the two experiments; in the experiment without adverb a negative correlation was found, whereas in the experiment with intervening adverb a positive correlation was found. This suggests that in the experiment without adverb with increasing age the preference for ungrammatical passages increased, whereas in the experiment with intervening adverb the preference for grammatical passages increased. These contradictory results could be explained by the aforementioned idea that novelty preferences are associated with easy learning tasks, whereas familiarity preferences are associated with more difficult tasks. The experiment with intervening adverb is expected to be more difficult, as two syllables intervene between the dependent morphemes. In this experiment a larger processing window is required to recognize the morphosyntactic dependencies than in the experiment without adverb. Recognizing the dependencies in the experiment without adverb is assumed to be easier, as the dependent morphemes are adjacent. It seems plausible that a familiarity preference is more frequently found in the experiment with intervening adverb, whereas a novelty preference is more frequently found in the experiment without adverb.

The moderate association between mouth behaviour and preference for grammaticality suggests that at-risk children with non-deviant mouth behaviour are more likely to show preference for grammaticality. However, the fact that no such associations were found between the other aspects of motor development and preference for grammaticality calls the value of this correlation into question. In contrast to Viholainen et al. (2002) no association was found between language and motor difficulties in at-risk children.

Three regression models were created to explain the variability in preference for grammaticality: a model with several language variables, a model with several non-language variables and a model with both language and non-language variables.

The language measures taken together explained quite a large part of the variability of the preference for grammaticality in the at-risk group in both experiments. This implies that the preference for grammaticality in these experiments can be predicted by expressive and receptive language skills. Generally, the results imply that better language skills are associated with a more significant preference for grammaticality in both groups. However, the language measures explained more of the variability in preference for grammaticality in the at-risk group than in the control group. This means that language skills of at-risk children are better predictors of preference for grammaticality than language skills of control children. Compared to controls, children at risk for dyslexia with good language skills are more likely to show a preference for grammaticality, whereas at-risk children with poorer language skills are more likely to show no preference. This was expected to be found if the 'delayed knowledge' explanation turned out to be the right explanation. The 'processing deficit' explanation would be supported by the opposite finding: more explained variability in the control group than in the at-risk group. Thus it seems that the finding by Wilsenach and Wijnen (2004) that at-risk children were not able to discriminate between grammatical and distorted dependencies should be explained by the fact that those children do not have the knowledge (yet) to recognize the morphosyntactic dependency.

The model with the non-language variables explained a smaller part of the variability in preference for grammaticality than the language variables. This suggests that preference for grammaticality is more dependent upon language-skills than upon non-language skills in both groups.

The model with both the language and non-language variables explained the largest proportion of the variability in preference for grammaticality in both groups. This suggests that all areas of development are bound; the progress in all these different domains influences preference for grammaticality.

The pattern of explained variability, however, differed in both experiments for the at-risk group. More of the variability in preference for grammaticality was explained in the experiment with intervening adverb than in the experiment without adverb in the three regression models. Thus the performance in the preferential listening experiment with intervening adverb was better predicted by the language and non-language variables than the performance in the experiment without adverb. This suggests that preference for grammaticality in the experiment with intervening adverb depends more upon age, general development, language skills and motor skills. Children with poorer general development, language development, motor development and/or lower age are less likely to show preference for grammaticality in the experiment with intervening adverb than in the experiment without adverb. This could to be due to a difference in difficulty between the two experiments. A larger processing window is required to show preference for grammaticality in the experiment with intervening adverb than in the experiment without adverb. The growth of the processing window is a developmental process. This suggests that the children are able to show preference for grammaticality in the experiment without adverb in an earlier stage of development than in the experiment with intervening adverb, as a smaller processing window is required to recognize the dependencies.

Furthermore, the model with the language variables and the model with the non-language variables predicted more of the variability in preference for grammaticality in the experiment without adverb in the at-risk group than in the control group. This is in line with the 'delayed knowledge' explanation (see above). In contrast, the model including all the variables predicted more of the variability in the control group than in the at-risk group. This seems to support the 'processing deficit' explanation, as this suggests that preference for grammaticality in the at-risk group is less dependent upon language and non-language skills than in the control group. The fact that still a large proportion of the variability is explained in the at-risk group could be due to the assumed subgroups in the at-risk group: a later dyslexic and a later non-dyslexic subgroup. The performance of the later non-dyslexic subgroup and the control group depends equally upon age, general development, language skills and motor skills. It is not clear how these contradictory results can be explained. Further research is needed to make valid conclusions about the sensitivity to morphosyntactic dependencies of at-risk children and more generally about language development, motor development and concentration. This research should include larger samples of at-risk and control children and should take into account the incidence of dyslexia in the at-risk group.

Conclusion

The main aim of this study could not be reached due to a failure in replicating the findings of Wilsenach and Wijnen (2004) that typically developing 19-month-old children are able to detect discontinuous dependencies. Because of this, nothing can be concluded about the underlying cause of the behaviour of at-risk children in their experiment. Nevertheless, from the present study can be concluded that at-risk children with a mean age of 20 months do not differ from typically developing age peers in sensitivity to grammatical dependencies, language skills, motor skills and concentration. However, it could be that the at-risk sample in this study comprises few later dyslexic at-risk children. Thus the incidence of dyslexia in both groups needs to be taken into account in future research. Another conclusion is that, in contrast to the findings of Wilsenach and Wijnen, typically developing children, aged around 20 months, are not (yet) sensitive to the grammatical dependency between the auxiliary 'heeft' and the past participle. However, further research is needed to find out whether these are valid conclusions. The fact that 18-month-old English and 19-month-old German children have been found to be able to detect suchlike discontinuous dependencies calls the validity of these conclusions in question even more. Furthermore, it should be taken into account that a failure in showing differential interest does not necessarily indicate a deficit. More experiments have to be conducted to get insight into the sensitivity to grammatical structures in at-risk children, especially by using several experimental methods and larger samples. If the preferential listening procedure will be used again, it is advised to adapt the experiment in such a way that both types of passages (i.e. with and without intervening adverb) are randomly presented, which ensures that the passages with and without adverb can be more safely compared. It could also be useful to make the experiment more attractive for young children, as it was frequently observed that the children did not like the experiments. Using a more lively voice will motivate the child to keep on listening.

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Appendixes

Appendix 1: Stimuli of the experiment with intervening adverb (Wijnen & Wilsenach, 2004)

Grammatical passages

1) De zon heeft geschenen. Iedereen heeft gespeeld. Het vrolijke meisje heeft gerend. Mama heeft gezwommen. De hond heeft gedronken uit zijn bak. De jongen heeft geschreeuwd toen hij uit de boom viel. Zijn zusje heeft gelachen. De hamster heeft gepiept. Papa heeft geharkt in de tuin. De arme groenteboer heeft gewerkt.

2) Het heeft geregend. De jongen heeft gehuild, omdat hij niet naar buiten mocht. Het kleine meisje heeft gespeeld. Mama heeft gestofzuigd in de kamer. Papa heeft gelezen. De jongen heeft gedoucht. De poes heeft gemiauwd. De hond heeft gegromd naar de poes. De baby heeft gelachen om de hond. Oma heeft gebreid.

3) De familie heeft gegeten. Iedereen heeft gekletst. Papa heeft geproefd van de soep. Het meisje heeft gezegd dat het goed smaakte. Tante heeft gesmuld. De jongen heeft gespoten met slagroom. Zijn neef heeft gegrinnikt. Oma heeft gedacht dat mama niet kon koken. Mama heeft geglimlacht en oma heeft gebloosd.

4) De haan heeft gekraaid op de boerderij. De stoute hond heeft geblaft. Het paard heeft gehinnikt. Het vieze varken heeft gevreten. De koe heeft gestaan in de wei. De boer heeft gewerkt. De boerin heeft gekookt en haar man heeft gegeten. De kip heeft gekakeld in het hok. De luie knecht heeft geslapen in het hooi.

5) De wind heeft gewaaid in het bos. De tijger heeft gelegen, maar een leeuw heeft gebruld. Het hert heeft geluisterd. De haas heeft gesprongen. De grote aap heeft gedronken bij de waterbron. De olifant heeft getrompetterd en de vogel heeft gezongen. De giraffe heeft geslapen. De hommel heeft gezoemd.

6) De familie heeft gewandeld. Iedereen heeft genoten. Opa heeft gelopen. Het kind heeft gehuppeld. Mama heeft gezocht naar eenden. De baby heeft gehuild. Haar broer heeft gezegd dat zij eenden eng vond. Papa heeft gezien dat het donker werd. De tweeling heeft gerend op straat tot oma ze heeft geroepen.

7) De agent heeft gezien wat iedereen heeft gedaan in het verkeer. De auto heeft gereden en de bus ook. Een man heeft gewacht op het stoplicht. Een kind heeft gestept. De vrachtauto heeft geremd. De fietser heeft gefietst. De dief heeft geprobeerd een tas te stelen. De vrouw heeft geroepen. Een man heeft geholpen.

8) Iedereen heeft geslapen. Opa heeft gedroomd over biefstuk en frietjes. Het kind heeft gegaapt. Oma heeft gedut. De wekker heeft gerinkeld. Papa heeft gedoucht. De jongen heeft geweigerd om op te staan. Mama heeft gezegd dat het toch moest. Zijn kleine broertje heeft geschreeuwd. Het hele gezin heeft gegeten.

Ungrammatical passages

1) De zon kan geschenen. Iedereen kan gespeeld. Het vrolijke meisje kan gerend. Mama kan gezwommen. De hond kan gedronken uit zijn bak. De jongen kan geschreeuwd toen hij uit de boom viel. Zijn zusje kan gelachen. De hamster kan gepiept. Papa kan geharkt in de tuin. De arme groenteboer kan gewerkt.

2) Het kan geregend. De jongen kan gehuild, omdat hij niet naar buiten mocht. Het kleine meisje kan gespeeld. Mama kan gestofzuigd in de kamer. Papa kan gelezen. De jongen kan gedoucht. De poes kan gemiauwd. De hond kan gegromd naar de poes. De baby kan gelachen om de hond. Oma kan gebreid.

3) De familie kan gegeten. Iedereen kan gekletst. Papa kan geproefd van de soep. Het meisje kan gezegd dat het goed smaakte. Tante kan gesmuld. De jongen kan gespoten met slagroom. Zijn neef kan gegrinnikt. Oma kan gedacht dat mama niet kon koken. Mama kan geglimlacht en oma kan gebloosd.

4) De haan kan gekraaid op de boerderij. De stoute hond kan geblaft. Het paard kan gehinnikt. Het vieze varken kan gevreten. De koe kan gestaan in de wei. De boer kan gewerkt. De boerin kan gekookt en haar man kan gegeten. De kip kan gekakeld in het hok. De luie knecht kan geslapen in het hooi.

5) De wind kan gewaaid in het bos. De tijger kan gelegen, maar een leeuw kan gebruld. Het hert kan geluisterd. De haas kan gesprongen. De grote aap kan gedronken bij de waterbron. De olifant kan getrompetterd en de vogel kan gezongen. De giraffe kan geslapen. De hommel kan gezoemd.

6) De familie kan gewandeld. Iedereen kan genoten. Opa kan gelopen. Het kind kan gehuppeld. Mama kan gezocht naar eenden. De baby kan gehuild. Haar broer kan gezegd dat zij eenden eng vond. Papa kan gezien dat het donker werd. De tweeling kan gerend op straat tot oma ze kan geroepen.

7) De agent kan gezien wat iedereen kan gedaan in het verkeer. De auto kan gereden en de bus ook. Een man kan gewacht op het stoplicht. Een kind kan gestept. De vrachtauto kan geremd. De fietser kan gefietst. De dief kan geprobeerd een tas te stelen. De vrouw kan geroepen. Een man kan geholpen.

8) Iedereen kan geslapen. Opa kan gedroomd over biefstuk en frietjes. Het kind kan gegaapt. Oma kan gedut. De wekker kan gerinkeld. Papa kan gedoucht. De jongen kan geweigerd om op te staan. Mama kan gezegd dat het toch moest. Zijn kleine broertje kan geschreeuwd. Het hele gezin kan gegeten.

Appendix 2: Stimuli of the experiment without adverb (Van der Ven, 2004)

Grammatical passages

1) De zon heeft helder geschenen. Het vrolijke meisje heeft buiten gerend. Mama heeft heerlijk gezwommen. De hond heeft dorstig gedronken uit zijn bak. De jongen heeft keihard geschreeuwd toen hij uit de boom viel. Zijn zusje heeft hardop gelachen. De hamster heeft eenzaam gepiept, want iedereen heeft elders gespeeld.

2) Het heeft vandaag geregend. De jongen heeft 's ochtends gehuild, omdat hij niet naar buiten mocht. Het kleine meisje heeft binnen gespeeld. Mama heeft vluchtig gestofzuigd in de kamer. Papa heeft echter gelezen. De jongen heeft lekker gedoucht. De poes heeft alweer gemiauwd. De hond heeft ineens gegromd naar de poes.

3) De familie heeft 's avonds gegeten. Iedereen heeft samen gekletst. Papa heeft even geproefd van de soep. Het meisje heeft meteen gezegd dat het goed smaakte. Haar broer heeft gulzig gesmuld. Oma heeft altijd gedacht dat mama niet kon koken. Mama heeft later geglimlacht en oma heeft bijna gebloosd.

4) De haan heeft 's morgens gekraaid op de boerderij. De stoute hond heeft aaneen geblaft. Het paard heeft 's middags gehinnikt. Het vieze varken heeft slordig gevreten. De koe heeft doodstil gestaan in de wei. De boer heeft harder gewerkt dan gisteren. De boerin heeft gezond gekookt en haar man heeft genoeg gegeten.

5) De wind heeft zachtjes gewaaid in het bos. De tijger heeft vreedzaam gelegen, maar een leeuw heeft ergens gebruld. Het hert heeft gespitst geluisterd. De haas heeft sierlijk gesprongen. De giraffe heeft rustig gedronken bij de waterbron. De olifant heeft luidkeels getrompetterd en de vogel heeft prachtig gezongen.

6) De familie heeft dikwijls gewandeld. Iedereen heeft ervan genoten. Opa heeft langzaam gelopen. Het kind heeft vooral gehuppeld. Mama heeft meestal gezocht naar eenden. De baby heeft verschrikt gehuild. Haar broer heeft gemeen gezegd dat zij eenden eng vond. Papa heeft verbaasd gezien dat het donker werd.

7) De agent heeft zoveel gezien! De auto heeft sneller gereden dan de bus. Het kind heeft netjes gewacht op het stoplicht. De vrachtauto heeft linksaf gereden. De fietser heeft steunend gefietst. De dief heeft zowaar geprobeerd een tas te stelen. De vrouw heeft angstig geroepen. Een man heeft bijtijds geholpen.

8) Iedereen heeft vannacht geslapen. Opa heeft snurkend gedroomd over biefstuk en frietjes. Het kind heeft doodmoe gegaapt. Oma heeft snuivend gedut. De wekker heeft 's ochtends gerinkeld. Papa heeft daarna gedoucht. De jongen heeft botweg geweigerd om op te staan. Mama heeft liefjes gezegd dat het toch moest.

Ungrammatical passages

1) De zon kan helder geschenen. Het vrolijke meisje kan buiten gerend. Mama kan heerlijk gezwommen. De hond kan dorstig gedronken uit zijn bak. De jongen kan keihard geschreeuwd toen hij uit de boom viel. Zijn zusje kan hardop gelachen. De hamster kan eenzaam gepiept, want iedereen kan elders gespeeld.

2) Het kan vandaag geregend. De jongen kan 's ochtends gehuild, omdat hij niet naar buiten mocht. Het kleine meisje kan binnen gespeeld. Mama kan vluchtig gestofzuigd in de kamer. Papa kan echter gelezen. De jongen kan lekker gedoucht. De poes kan alweer gemiauwd. De hond kan ineens gegromd naar de poes.

3) De familie kan 's avonds gegeten. Iedereen kan samen gekletst. Papa kan even geproefd van de soep. Het meisje kan meteen gezegd dat het goed smaakte. Haar broer kan gulzig gesmuld. Oma kan altijd gedacht dat mama niet kon koken. Mama kan later geglimlacht en oma kan bijna gebloosd.

4) De haan kan 's morgens gekraaid op de boerderij. De stoute hond kan aaneen geblaft. Het paard kan 's middags gehinnikt. Het vieze varken kan slordig gevreten. De koe kan doodstil gestaan in de wei. De boer kan harder gewerkt dan gisteren. De boerin kan gezond gekookt en haar man kan genoeg gegeten.

5) De wind kan zachtjes gewaaid in het bos. De tijger kan vreedzaam gelegen, maar een leeuw kan ergens gebruld. Het hert kan gespitst geluisterd. De haas kan sierlijk gesprongen. De giraffe kan rustig gedronken bij de waterbron. De olifant kan luidkeels getrompetterd en de vogel kan prachtig gezongen.

6) De familie kan dikwijls gewandeld. Iedereen kan ervan genoten. Opa kan langzaam gelopen. Het kind kan vooral gehuppeld. Mama kan meestal gezocht naar eenden. De baby kan verschrikt gehuild. Haar broer kan gemeen gezegd dat zij eenden eng vond. Papa kan verbaasd gezien dat het donker werd.

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8) Iedereen kan vannacht geslapen. Opa kan snurkend gedroomd over biefstuk en frietjes. Het kind kan doodmoe gegaapt. Oma kan snuivend gedut. De wekker kan 's ochtends gerinkeld. Papa kan daarna gedoucht. De jongen kan botweg geweigerd om op te staan. Mama kan liefjes gezegd dat het toch moest.