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Development of oral language skills in children at familial risk of dyslexia from toddlerhood to school age

Associations, Predictors, and Outcomes

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Summary

A long line of research has shown that early oral language skills, including vocabulary and grammar, lay the foundation for later reading and writing ability and that children with poor oral language skills at the time of school entry are at heightened risk for later language and reading-related problems. Research focusing on the longitudinal development of lexical and grammatical skills in children born at familial risk of dyslexia and the potential effect of home literacy environment (HLE) on these children's oral language has been limited thus far. The current doctoral study therefore tracked a cohort of family risk children (FR) and their peers with no such risk (NoFR) from age 18 months up to the age of school entry (i.e., 6 years) and examined the growth of vocabulary and grammar skills and the possible effect of HLE on them. The study further examined whether and how these two core components of oral language are linked and interact with one another over time.

The three empirical studies that comprise this thesis are based on data from the Tromsø Longitudinal Study of Dyslexia. Children were assessed at seven time-points using standardized tests and parental reports. The first study aimed to explore the development of lexical and grammatical skills between ages 1;6 and 6 years to find out whether children with FR and NoFR differed from each other. Results showed that the two groups had a similar development in the earlier years. However, FR status seemed to have a significantly negative association with vocabulary and grammar scores at age 6 years, resulting in language outcomes in favour of NoFR children. The second study aimed to investigate whether FR status and late talker status (LT), which was established at age 2 years, affected language skills at ages 4;6 and 6 years and whether the possible effect of LT status differed depending on children's FR status. Results revealed an effect of LT on language at both ages, whereas FR status affected language skills only at age 6 years. Results further showed that LT status affected oral language skills regardless of whether the child had a family history of dyslexia or not. Moreover, the results indicated that a proportion of FR children developed late emerging language difficulties by school entry, despite having typical vocabulary skills in toddlerhood. This was not the case in the NoFR group. The third study in the thesis tested the potential longitudinal effects of HLE on later language development. More precisely, we examined to what extent, if any, book exposure and child's own interest in book reading would affect vocabulary and grammar skills. Results showed that child's own interest in book

reading did not have an effect on language skills in either group, while book exposure seemed to contribute to vocabulary skills only in the FR group by school entry. However, this association was fully mediated by lexical skills at age 4;6 years, implying that exposure to books had a positive indirect effect on FR children's later language development through its effects on early vocabulary knowledge.

Taken together, the results of the present thesis showed that FR children, as a group, had poorer oral language skills than their NoFR peers, though not early in development but towards the end of the preschool period. Notably, some FR children with typical early language skills seemed to develop late emerging language difficulties. These findings suggest that having FR may place children at increased risk for developmental language disorder, and thus emphasise the importance of having a continuous focus on the development of oral language skills in FR children, specifically in the years preceding formal schooling. This may, in turn, contribute to early identification of language and reading problems and provision of timely intervention.

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List of publications

Article 1:

Caglar-Ryeng, Ø., Eklund, K., & Nergård-Nilssen, T. (2019). Lexical and grammatical development in children at family risk of dyslexia from early childhood to school entry: a cross-lagged analysis. *Journal of Child Language, 46*(6), 1102-1126.

Article 2:

Caglar-Ryeng, Ø., Eklund, K., & Nergård-Nilssen, T. (2019). School-entry language outcomes in late talkers with and without a family risk of dyslexia.

(Resubmitted after peer review to *Dyslexia: An International Journal of Research and Practice*)

Article 3:

Caglar-Ryeng, Ø., Eklund, K., & Nergård-Nilssen, T. (2019). The effects of book exposure and reading interest on oral language skills of children with and without a familial risk of dyslexia.

(Resubmitted after peer review to *Dyslexia: An International Journal of Research and Practice*)

1 Introduction

1.1 Background and aim

“Language is an art, like brewing or baking; but writing would have been a much more appropriate simile. It certainly is not a true instinct, as every language has to be learnt. It differs, however, widely from all ordinary arts, for man has an instinctive tendency to speak, as we see in the babble of our young children; whilst no child has an instinctive tendency to brew, bake, or write” (Darwin, 1871, p. 55).

As aptly depicted in the quote above, unlike spoken language, which is acquired without being specifically taught, written language must be learned with explicit instructions. One reading of this statement is that oral language skills develop prior to literacy skills. However, despite being two distinct set of skills, many lines of evidence point towards a close link between them from preschool age to adolescent years in both typically and atypically developing children (Catts & Kamhi, 2005; Kamhi & Catts, 2012; Stone, Silliman, Ehren, & Wallach, 2014). In line with this, research has further indicated that oral skills lay the foundation for later reading and writing ability (Hjetland et al., 2019; Hulme, Nash, Gooch, Lervåg, & Snowling, 2015; Storch & Whitehurst, 2002; Treiman, Cassar, & Zukowski, 1994; Treiman & Kessler, 2014). The corollary of this is that children with oral language capacity, which is less well-developed than that of their age peers at the time of school entry have an increased risk of facing reading-related problems (Bishop & Adams, 1990; Bishop & Snowling, 2004; Law, Rush, Schoon, & Parsons, 2009; Thompson et al., 2015; Tomblin, Zhang, Buckwalter, & Catts, 2000).

Moreover, the fact that acquisition of knowledge in most school subjects is through reading and comprehending written texts makes these children relatively more vulnerable in terms of long-term educational attainments (Maughan et al., 2009; McLaughlin, Speirs, & Shenassa, 2014; Ricketts, Sperring, & Nation, 2014). Therefore, early identification of potential language difficulties and provision of timely intervention are of utmost importance in order to prevent at-risk children from facing a downward spiral of poor language, poor reading, and poor academic outcomes.

Children born into families with a history of dyslexia are among those who are at greater risk for future literacy problems (Snowling & Melby-Lervåg, 2016). It is now widely accepted that the risk of inheriting dyslexia depends on the combined influence of many genes of small effect, as well as environmental influences, pointing out the multifactorial aetiology of dyslexia (Bishop, 2009; Hulme & Snowling, 2009; Pennington, 2006). Aligning well with this multifactorial conceptualization, research has shown that although children with family risk seem to share phonological deficits to varying degrees (Snowling & Melby-Lervåg, 2016), it is mostly when such deficits combine with other difficulties that dyslexia is the outcome (Snowling, 2019). In line with this, family risk children who also have weaknesses in their broader language skills (e.g., vocabulary and grammar) are reported to be more likely to develop dyslexia, highlighting the influence of these skills on later reading development (Carroll, Mundy, & Cunningham, 2014; Scarborough, 1990; Snowling, Gallagher, & Frith, 2003; van Viersen et al., 2017).

Prospective family studies have further revealed that samples of children with family risk of dyslexia show higher incidence of preschool language difficulties (Nash, Hulme, Gooch, & Snowling, 2013; Snowling et al., 2019), which often leads to a diagnosis of developmental language disorder (DLD; Bishop et al., 2017). This particular result, that a portion of these children are also at high risk of developing DLD, which typically manifests itself as a difficulty in acquiring lexical and grammatical skills (Leonard, 2014), underscores the importance of tracking language development in those with familial risk from early on. Relatedly, findings from intervention research point out that children who remain poor readers in spite of extra support (also referred to as treatment non-responders) are typically those who not only have severe phonological impairments, but also poor oral language skills (Al Otaiba & Fuchs, 2006; Carroll, Bowyer-Crane, Duff, Hulme, & Snowling, 2011).

At this point, it should be mentioned that when considering problems in reading development a clear distinction between decoding (the accuracy and fluency of reading aloud) and comprehension (the adequacy of understanding text) is important. Problems in learning to decode (dyslexia) and problems in learning to comprehend text (reading comprehension impairment) are both predominantly caused by deficits in underlying language skills. As will be discussed in the next chapter, dyslexia is associated with early problems in oral language development, with persistent problems in phonological skills. In contrast, reading comprehension impairment depends critically upon broader oral language difficulties;

particularly problems with vocabulary and grammar skills. Notably, many children may experience difficulties in both components of reading (Hulme & Snowling, 2016). This distinction between the two forms of reading disorder is relevant for the current results and the potential implications they may have for educational practice.

Taken together, empirical evidence suggests that difficulties in oral language development put children at heightened risk for later language and reading problems. Furthermore, multifactorial models, which will be discussed in detail below, suggest that environmental influences can act as additional protective or risk factors in development of dyslexia (Pennington, 2006; van Bergen, van der Leij, & de Jong, 2014). Based on this, one might ask to what extent oral skills in children at family risk of dyslexia are affected by their home literacy environment (HLE). Relatedly, it may also be asked whether HLE contributes relatively more to these children's oral language development in the preschool period, as this, in turn, might help them to compensate for their vulnerability to later reading difficulties. Surprisingly, longitudinal data regarding this issue are not only scarce but also mixed, and there is need for more research (Dilnot, Hamilton, Maughan, & Snowling, 2017; Snowling & Melby-Lervåg, 2016; Torppa et al., 2007).

To date, research concerning the longitudinal development of oral language in family risk children with a specific focus on lexical and grammatical skills as well as the potential effect of HLE has been limited, especially in comparison with research that has focused on phonological skills in this group of children (Adlof & Hogan, 2018). The current doctoral thesis therefore attempts to address this gap in the extant literature by providing more insight into the growth of these two core components of oral language and the ways in which they are linked and interact with one another over time.

The present study tracked the development of oral language in a cohort of family risk (FR) children and their peers with no such risk (NoFR) from age 18 months up to the age of school entry (i.e., 6 years) using measurements from seven time-points. The overarching aim is to examine whether and how having a FR of dyslexia exerts an effect on vocabulary and grammar development in preschool children, and whether early skills and HLE contribute to predicting individual variation in subsequent language outcomes differently depending on FR status. In doing so, the current research could lead to a better understanding of the possible effect of family risk not only on the developmental patterns of broader language skills, but also on how early skills relate to later language development in this group of children. This may, in turn, contribute to the knowledge base informing early identification and intervention programs conducted in preschool and school settings. In addition to the fact that the current study with FR children is the first of its kind in the Norwegian context, it also provides longitudinal data on the development of vocabulary and grammar in typical children from toddlerhood to school entry age, which are reported to be sparse in Norwegian (Simonsen, Kristoffersen, Bleses, Wehberg, & Jørgensen, 2014).

The present thesis is based on three empirical studies, which are reported in three papers. Each study contributes to the overarching aim in a unique way with their respective research questions, as briefly described here. Study I explored the development of vocabulary and grammar skills between ages 1;6 and 6 years to find out whether FR and NoFR children differed from each other. It further explored whether there were any temporal interdependencies between lexical and grammatical growth across this period. In doing so, Study I provided not only an overall picture of skill development for the whole observation period, but also a deeper insight into the nature of concurrent, predictive, and cross-lagged associations between vocabulary and grammar.

Because the results of Study I revealed differences between the two groups based on their FR status only at the end of the assessment period, a more straightforward risk factor (i.e., late talker status) for subsequent language development was considered in Study II. More specifically, Study II investigated the potential effect of late talker status on oral skills to determine whether such an effect would be apparent from an earlier age, and whether it would differ depending on children’s FR status. Study II further examined the extent to which FR and late talker status, respectively, explained variation in language outcomes at school-entry age.

The results from Study I and Study II showed a significant effect of FR and late talker status on language skills, though at varying time points. These two risk factors, which appear to exert an effect on language development, are both inherent in the child. In Study III, on the other hand, we sought to explore the possible longitudinal effects of home literacy environment on subsequent language development. More precisely, Study III examined to what extent exposure to books and interest in book reading would affect vocabulary and grammar development. To this end, Study III compared FR and NoFR children and examined whether the potential influence of these two HLE-factors was different depending on children's FR status and earlier language abilities.

1.2 Clarification of terms

In the current research, the term *broader oral language skills* is used to refer to vocabulary and grammar skills only. Although broader oral language includes other skills as well, such as narrative and discourse skills, they are beyond the scope of this thesis. The term *vocabulary* is used to refer to the number of words the child produces (i.e., vocabulary breadth). A theoretical distinction has been suggested between vocabulary breadth, and vocabulary depth, that is, how well the child knows the meanings of words (Ouellette, 2006). However, due to the nature of the language measures opted for the assessment of vocabulary, the issue of vocabulary depth is not within the scope of this study. As for the term *grammar*, it is used to refer to both morphology and syntax together. This is due to the fact that the grammar scores reported in this thesis were based on language measures tapping both morphological and syntactic skills in children.

Children who participated in this research were not tested for reading-related or language-related disorders yet, thus had no diagnosis. In Paper II, in agreement with a reviewer's suggestion, the terms *at risk of developmental language disorder* and *emerging developmental language disorder* are adopted. They are used to refer to clinically significant oral language weakness (i.e., -1 *SD* below the mean) not tied to a specific diagnostic label (please see Method section in Paper II for further details). Furthermore, in line with recent recommendation for the use of DLD as the established term for children whose language difficulties cannot be accounted for by physical, cognitive or neurological causes (Bishop et al., 2017), this thesis utilizes the terminology of DLD, both in reference to our subsamples with language difficulties and in reference to previous literature.

1.3 Outline of the thesis

The present thesis consists of an extended abstract and three articles. The extended abstract comprises five chapters in addition to the current introductory one. Chapter 2 presents the prominent theoretical models of dyslexia, language acquisition, and the relationship between underlying language difficulties and reading disorders. Chapter 3 addresses the methodological issues with respect to the three articles in the thesis. Chapter 4 summarises each article and presents the associated research questions. Chapter 5 provides a general discussion of the main findings in light of the theoretical models presented in chapter 2. Finally, the extended abstract ends with some practical implications and concluding remarks provided in Chapter 6. The three empirical studies (Articles I-II-III) are presented at the end of the thesis.

2 Theoretical perspectives

Each article in the thesis provides a review of prior studies and findings relevant for the research questions that they have addressed. In order to avoid iterating the already introduced and discussed topics, this chapter instead presents and discusses the overarching theories and models, which relate to development of dyslexia, language acquisition, and the relationship between underlying language difficulties and reading disorders. Although not directly tested in the current study, these theories and models have been presented to help frame the discussion of main findings. Chapter starts with the presentation of a widely recognised multiple deficit model of dyslexia. It further provides a discussion of the role of genetic and environmental factors and their interaction in the development of the disorder. Next, two prominent theories of language acquisition have been reviewed. Thereafter, development of oral language skills in children with FR and children with DLD has been outlined separately. Finally, two theoretical models, which account for different forms of reading problems in children have been presented. These models are included here as they help better understand how oral language difficulties relate to reading disorders.

2.1 Development of dyslexia within a multifactorial framework

Dyslexia is a developmental language-based learning disorder characterized by difficulties with accurate and/or fluent word recognition and spelling, which are not due to lack of adequate reading instruction (Lyon, Shaywitz, & Shaywitz, 2003; Peterson & Pennington, 2012). Within the population, reading skills are normally continuously distributed, and dyslexia is considered to represent the lower tail of this distribution (Gilger, Borecki, Smith, DeFries, & Pennington, 1996). Accordingly, dyslexia "is best thought of as a continuum, not a distinct category, and there are no clear cut-off points" (Rose, 2009, p. 10). As such, prevalence estimates depend largely on criteria for the severity of reading difficulties and range from 5 to 17% of school age population. This indicates that dyslexia is one of the most common learning disorders (Fletcher, 2009; Shaywitz & Shaywitz, 2005).

Over decades, a large body of research has been directed toward identifying the causal basis of dyslexia (Elliott & Grigorenko, 2014, for an overview). A number of theories, which are mainly formulated within a single-factor causal model, have been proposed (Ramus et al., 2003, for a review), including: the auditory processing theory (Tallal, 1980, 2000), the visual theory (Lovegrove, Martin, & Slaghuis, 1986), the cerebellar theory (Nicolson & Fawcett, 1990), and the phonological theory (Liberman, Shankweiler, & Liberman, 1989; Snowling, 1981). Among these theories, the phonological deficit theory has received the most attention (Snowling, 2000; Vellutino, Fletcher, Snowling, & Scanlon, 2004). In this account of dyslexia, the ability to attend to and manipulate speech sounds (phonemes) is vital to establish and automatize letter-sound correspondences, which in turn underlie accurate and fluent word recognition through the process of phonological coding in alphabetic languages (Peterson & Pennington, 2012). Accordingly, this theory argues that a deficit in the phonological system of language is the proximal cause of reading problems in dyslexia. Much research has provided evidence that children and adults with dyslexia often have a deficit in their phonological processing skills, particularly in phonological awareness (Hulme & Snowling, 2009; Puolakanaho et al., 2007; Ramus et al., 2003).

However, in recent years it has been increasingly recognized that a single phonological deficit is neither sufficient to cause dyslexia (McGrath et al., 2011; Pennington, 2006; Pennington et al., 2012; van der Leij et al., 2013) nor can explain adequately all behavioural symptoms associated with the disorder (Ramus & Ahissar, 2012). For example, although phonological difficulties are quite common in dyslexia, there is also evidence that some children who are classified as dyslexic have indeed no history of phonological deficits and some children with phonological deficits do not develop dyslexia (Catts, McIlraith, Bridges, & Nielsen, 2017; Pennington et al., 2012; Snowling, 2008).

Moreover, a single deficit model does not readily account for the observation that dyslexia is frequently comorbid with other neurodevelopmental disorders, such as speech sound disorder and DLD (Pennington & Bishop, 2009). These findings together with other similar findings have led investigators to consider the development of dyslexia within a multifactorial framework rather than in monocausal models (Catts & Adlof, 2011; Catts et al., 2017; Moll, Loff, & Snowling, 2013; Pennington, 2006; Snowling, 2008; van Bergen et al., 2014).

In a comprehensive paper, Pennington (2006) has proposed a multiple deficit model for dyslexia. Pennington argues that like all other behaviourally defined developmental disorders, the aetiology of dyslexia is complex and multifactorial. It involves several interacting risk and protective factors, which can be genetic and/or environmental. These etiological factors alter the development of cognitive functions, which are necessary for normal development and produce the behavioural symptoms of the disorder.

Pennington (2006) further argues that etiological factors operate probabilistically, that is, while risk factors increase the likelihood of the disorder, protective factors decrease it. In this multiple deficit model, no single risk factor necessarily leads to dyslexia, and several risk factors need to be present for the disorder to manifest itself. Because some of these etiological and cognitive risk factors are shared with other developmental disorders (e.g., attention deficit hyperactivity disorder, speech sound disorder, DLD), comorbidity is expected between them and dyslexia. Notably, Pennington's model also proposes that "the liability distribution for a given disease is often continuous and quantitative, rather than being discrete and categorical, so that the threshold for having the disorder is somewhat arbitrary (Pennington, 2006, p. 404)". It should be mentioned that van Bergen et al. (2014) have recently extended Pennington's (2006) model and proposed an intergenerational multiple deficit model in which both parents confer child's liability for reading disability via intertwined genetic and environmental pathways. Results from FR studies of dyslexia appear to provide empirical evidence for these models.

Across languages, an important finding from FR studies is that at-risk children who turned out to have literacy impairments obtain significantly lower scores on tasks measuring phonological awareness than NoFR children, while FR children without literacy impairments score in-between these two groups (Boets, Wouters, van Wieringen, & Ghesquiere, 2007; Elbro, Borstrøm, & Petersen, 1998; Pennington, & Lefly, 2001; Snowling et al., 2003; van der Leij et al., 2013). This result implies that, as proposed by the multiple deficit model, genetic liability of dyslexia is distributed continuously and unaffected children, like affected at-risk children, inherit certain etiological risk factors, though to a lower extent. It is worth noting though that while some prospective studies of FR provided partial support for this step-wise pattern (van Bergen et al., 2011), others found no significant differences between FR non-dyslexic and control groups (Torppa, Lyytinen, Erskine, Eklund, & Lyytinen, 2010).

Consistent with the multiple deficit model, comparison of affected vs. unaffected FR children has further revealed that those with dyslexia experience delays and difficulties in their vocabulary and grammar in the preschool years (Carroll et al., 2014; Catts, Fey, Zhang, & Tomblin, 1999; Gallagher, Frith, & Snowling, 2000; Lyytinen et al., 2006; Scarborough, 1990; Moll et al., 2013; Snowling et al., 2003; van Bergen et al., 2014). In interpreting their results, Snowling et al. (2003) have proposed that although the majority of FR children may have phonological deficits, whether they develop dyslexia will depend on their broader oral language skills. In other words, FR children who have poor phonological skills (one risk factor) and also poor oral language (additional risk factor) are more likely to develop dyslexia than FR children who have poor phonology, but show normal oral language development (Snowling, 2011). Based on the results that unaffected at-risk children had normal vocabulary and grammar skills despite their weaknesses in phonological processing skills, Snowling and colleagues (2003) have further argued that these children seem to be protected from reading difficulties because of their relative strengths in broader oral language skills. At this point, it is important to note that FR children who develop dyslexia without comorbid DLD tend to have poorer scores on oral language tests; however, they typically do not show the kinds of grammatical restrictions seen in DLD (Bishop & Snowling, 2004), and their weaknesses in oral skills do not seem to reach the threshold for a diagnosis of language disorder.

That said, however, as proposed in Pennington's (2006) model, various pairs of developmental disorders share some risk factors, which produce a greater than expected co-occurrence between them. Of particular interest here is the high comorbidity observed between dyslexia and DLD, which primarily has adverse effects on the development of lexical and grammatical skills (Bishop, McDonald, Bird, & Hayiou-Thomas, 2009; Catts, Adlof, Hogan, & Weismer, 2005; McArthur, Hogben, Edwards, Heath, & Mengler, 2000). As will be discussed in section 2.5, it has been argued that there exist multiple deficits underpinning dyslexia and DLD. However, poor phonological processing seems to be the underlying deficit common to both disorders, leading to a co-occurrence more than expected by chance between them (Bishop & Snowling, 2004).

High rates of comorbidity has been reported in preschool FR samples (Gooch, Hulme, Nash, & Snowling, 2014). In a prospective study, Nash et al. (2013) has reported that approximately one-third of the children with FR of dyslexia met diagnostic criteria for DLD when they were 3;6 years old, suggesting a higher risk for developing a language disorder in samples of FR children. In support of this result, a recent study (Snowling et al., 2019) following-up the same FR sample further reported that 58% the children who developed dyslexia had also DLD at age 8 years. Moreover, of the children with dyslexia, 76% had significant language difficulties at age 5;6 years, suggesting that comorbid conditions between dyslexia and DLD observed in the longitudinal FR studies depend crucially on children's age and the stage of development they reached (Snowling et al., 2019).

Last but not least, Pennington's model also illustrates well the relevance and importance of the current study with Norwegian FR children. Because the children in this study were still in the pre-reading stage and not classified as dyslexic or not, the group differences were calculated based on FR status. As such, the present results do not deal with the behavioural precursors of the disorder itself. However, with the continuity of the genetic liability of dyslexia in mind, it is still valuable to examine oral language development in children with FR status from early on, as such results could add to the knowledge base concerning the markers of family risk in early childhood. Moreover, a longer-term follow-up of the current sample is under way. Therefore, the present findings could be informative in interpreting those data, which will be used to study the possible pathways between early language skills and later reading outcomes.

Furthermore, in line with the multifactorial nature of reading difficulties, broader oral language skills are argued to play a key role both as a protective factor decreasing the probability of dyslexia and as a risk factor increasing it. Relatedly, having problems in oral language skills is assumed to be an additional risk factor, which may put FR children at higher risk for DLD in addition to their genetic risk for dyslexia. Thus, our results could provide information as to whether a proportion of the FR children in the current study are at risk of experiencing problems not only in learning to decode but also in comprehending written texts.

2.2 The aetiology of dyslexia

Aetiology consists of genetic and environmental risk and protective factors and their interplay that act in development to produce outcome differences among individuals (Pennington & Peterson, 2015). In the case of dyslexia, it has long been known that there is a heritable genetic component, although the biological cause of the disorder is not entirely understood yet (DeFries, Fulker, & LaBuda, 1987; Olson, 2011). In support of this, a recent meta-analysis reported that children with a family history of dyslexia are four times more likely to experience reading problems than peers with no such family history (Snowling & Melby-

Lervåg, 2016). While prevalence rates of dyslexia in the school age population range from 5% to 17% (Shaywitz & Shaywitz, 2005), children with FR have a 29-66% chance of being affected (Snowling & Melby-Lervåg, 2016), indicating that having a family history is a vital risk factor.

A wealth of data from behavioural genetics studies have shown that estimates for the heritability of reading ability range from 47% to 84% (Taylor, Roehrig, Hensler, Connor, & Schatschneider, 2010; Byrne et al., 2009, respectively), and importantly, genetic correlation for reading seems to increase significantly with age. For example, Logan et al. (2013) reported in their twin study that heritability of individual differences in reading increased from 22% at 6 years to 82% at age 12 years. These results together suggest that development of reading is mainly influenced by genetic factors. Consistent with this, several genes of small effects have been reported to be potential candidates for dyslexia susceptibility (Mascheretti et al., 2014; Paracchini, Scerri, & Monaco, 2007).

However, it is important to note that these genetic influences are associated with reading across the population and are not dyslexia-specific (Snowling & Hulme, 2015). Some of the candidate genes appearingly contribute to speech and language disorders as well, thus helping to account for the comorbidity of dyslexia with such disorders (Pennington, McGrath, & Peterson, 2019). Similarly, research by Plomin and colleagues has suggested that approximately 70% of the genes affecting reading disability also affect other learning disabilities in mathematics and language (Kovas & Plomin, 2007; Plomin & Kovas, 2005). However, while much of this overlap was due to so-called generalist genes, there were also specialist genes, of which influences were specific to reading and specific to other respective learning disabilities (Kovas et al., 2007), hence, contributing to disassociations among them.

Even though genetic factors has a substantial role to play in the aetiology of dyslexia, the reported heritability is less than 100%, suggesting that environmental factors and their interplay with genes also influence the development of the disorder. Based on the fact that families share not only genes, but also environments, possible candidates of shared environment include the language and preliteracy environments that parents provide for their children in the preschool years (Peterson & Pennington, 2015). In this regard, it can be expected that parents with dyslexia may provide a different, perhaps less optimal, HLE compared to that found in homes where parents do not have dyslexia. This may, in turn, have long-term effects on the development of children's language and literacy skills. As mentioned earlier, data on the potential relationship between FR and HLE have been limited thus far and seem to point towards somewhat mixed results (Snowling & Melby-Lervåg, 2016). Some researchers have reported less advantageous HLE in FR families compared with NoFR families (Dilnot et al., 2017, Esmaeeli, Lundetræ, & Kyle, 2018; Hamilton, Hayiou-Thomas, Hulme, & Snowling, 2016). However, others have found no differences (Elbro et al., 1998; Torppa et al., 2007; Torppa, Eklund, van Bergen, & Lyytinen, 2011; van Bergen et al., 2011), thus, arguing that HLE is not likely to be a risk factor in the development of dyslexia (van der Leij et al., 2013). This issue that whether FR and NoFR families differ in terms of their HLE and whether HLE, depending on FR status, exerts different effects on oral language development was addressed in Paper III.

With respect to the possible explanations for how genetic (G) and environmental (E) factors may act together, Pennington and Peterson (2015) argue that there are particularly two types of interplay between these factors, which are important to better understand the development of reading difficulties. They are, namely, GxE interaction, and, G-E correlation, which are also of relevance for the interpretation of results presented in the current thesis. Pennington and Peterson (2015) maintain that in GxE interaction, the independent effects of genes and environments are synergistic rather than additive. For example, research has evidenced that the heritability of dyslexia increases as parent education and socioeconomic status (SES) increase. This suggests that the child's HLE is both more favourable and less variable as parent education and SES increase, resulting in genetic risk factors playing a bigger role in the development of dyslexia (Friend, DeFries, & Olson, 2008; Friend et al., 2009). On the other hand, when parental education and SES decrease, HLE becomes less advantageous and more variable, causing environmental risk factors to play a larger role in children's reading problems (Friend et al., 2008; Friend et al., 2009).

In G-E correlation, the child and environment are in a transactional process in which they mutually alter each other over time (Peterson & Pennington, 2015). Such transactions occur because children not only evoke different kinds of reactions from their environments, but also they actively select different types of environments for themselves, and the individual characteristics of children, which affect such reactions and selections seem to be genetically influenced (Scarr & McCartney, 1983, cited in Peterson & Pennington, 2015). Three subtypes of G-E correlation have been suggested (Scarr & McCartney, 1983): passive, evocative, and active.

An example of passive G-E correlation (from the child's perspective) is the relation between parents' reading skills and the number of books in home. Parents who are poor readers, partly due to genes, may tend to buy fewer books regardless of their child's reading skills. In other words, without any action on the part of their biological offspring, HLE created by parents is correlated with their own reading genotype. On the other hand, evocative G-E correlation occurs, for example, when parents notice that their children have interest in reading related activities, thus seek to foster this by taking her/him to library or buying more children's books. In active G-E correlation, children, on their own initiative, seek or avoid literacy environments as a function of their own genotype. For example, FR children, particularly those who will later develop dyslexia, may avoid been read to and generally show less interest in books compared to their peers with NoFR. It is important to highlight that in comparison with HLE, less research attention has been paid to the possible effects of reading interest on preschool children's language and literacy acquisition, and the extant literature is not conclusive (Bracken & Fischel, 2008; Hume, Lonigan, & McQueen, 2015; Sparks & Reese, 2013). Study III in the present thesis addresses this question and examines whether the level of interest in book reading seems to differ between children with and without FR.

2.3 Development of language as an emergent system

The current observation period spans from age 18 months, a time when the majority of children have recently produced their first words, to the age of 6 years when most children have essentially mastered the sound system of their language, acquired thousands of words, and can speak in grammatically complete and fully intelligible sentences. A variety of mechanisms that may underlie this rapid learning of language have been proposed. These mechanisms can be mainly viewed in accord with either *nativism* or *emergentism/interactionism*, which are currently the two predominating theoretical frameworks in the study of language acquisition (Abbeduto, Evans, & Dolan, 2001; Clark, 2019; Hoff, 2014; MacWhinney, 2015).

In the nativist approach, language is seen as an innate ability, residing in the human genetic code. Accordingly, the research emphasis is placed on identifying the universal, stable, orderly, stage-like patterns in children's language (Evans, 2007). According to this approach, language is traditionally composed of phonological, semantic and syntactic components, which are describable in terms of different sets of abstract, context-free, deterministic units and rules (Abbeduto et al., 2001). It follows that these components are largely modular with minimal interactive communication between them (Fodor, 1983; MacWhinney, 2010). Due to this so-called modularity, these components, in a sense, are not being influenced by information from other domains of cognition during the course of acquisition. For example, it is thought that syntactic developments reflect almost exclusively the operation on the input of mechanisms that are only for acquiring syntax, so that their operation is not affected by more general learning mechanisms or by developments in non-linguistic cognition (Abbeduto et al., 2001; Chomsky, 1988). With respect to the role of environmental input in language development, the nativist view claims that language experience simply triggers the child's innate knowledge of universal properties of language, and sets language-specific parameters (Hoff, 2014). As a result, the nativist framework argues for a domain-specific learning mechanism, which is, in principle, only for language.

On the other hand, the emergentist framework includes a variety of positions, which share the assumption that linguistic structures are not innate, but emerge from patterns of usage across time (MacWhinney, 2015). In other words, emphasizing the richness of the input to the learner, the emergentist approach maintains that language acquisition occurs directly as a result of real time language use, which takes place within meaningful communicative contexts (Abbeduto et al., 2001). In this account, language acquisition is a learning problem that children solve in the same way they solve other learning problems, i.e., by using general learning and reasoning abilities that apply across domains (Hoff, 2014). Thus, the learning mechanisms that yield language are domain-general. These learning mechanisms are constrained to operate over some types of input but not others, as a function of the child's level of perception and cognition at any point in development (Saffran & Thiessen, 2007). Therefore, the basic premise in the domain-general approach is that language must be served by a distributed neural system that overlaps and interacts with virtually all cognition, namely, attention, memory, social cognition, executive control, emotion, and motivation. It follows that language cannot be discretely and fully localized in the brain from birth, but the neural substrates in the brain mechanisms change and get gradually specialized as language is learned (Pennington et al., 2019), contrary to the notion of innate language modules mentioned above.

This emergentist view of interactive specialization of language in the brain mechanisms is also in line with the standpoint that language acquisition is an example of complex self-organizing dynamic system (van Geert, 2010). Language acquisition process includes many components (e.g., phonemes, morphemes, syntax, lexicon, discourse), of which properties change continuously. This change is due to the recursive interactions taking place not only among the components themselves, but also between the components and the external language learning environment (Evans, 2007). The nature of the interplay between components that governs their dynamics over the long term of developmental time might be various, such as supportive, neutral or conditional (van Geert, 2010). A detailed discussion of these various types of interplay is beyond the scope of the current study. However, an example, which is also relevant for the first paper in the thesis, is the supportive relationship from lexicon to grammar. In this type of relationship, grammatical knowledge increases proportional to the size of the lexicon, meaning that greater lexicons have a stronger effect on increase in grammatical competence than smaller ones. In effect, the relationship between the lexicon and the grammar is more likely to be symmetrical due to the dynamic interplay among the system's components, meaning that the lexicon positively affects grammar and grammar positively affects the lexicon (van Geert, 2010).

These types of cross-domain effects are often accounted for by mechanisms referred to as lexical bootstrapping (Dale, Dionne, Eley, & Plomin, 2000) and syntactic bootstrapping (Gleitman, 1990; Naigles, 1990; Naigles & Swensen, 2007), as discussed in detail in Paper I. Taken together, the examples of bootstrapping effects mentioned above suggest that earlier developments and genetically based characteristics in one domain may provide the foundation for subsequent developments in other domains (Hoff, 2014). Thus, a dynamic system can be taken as a way to explain how the next state of the system emerges as a result of its preceding state (van Geert, 2011). However, in reality, as van Geert (2010) puts, a dynamic system like language tends to be much more complicated and includes more than two constituents. Such a complex system would therefore comprise, among others, the relationship between lexicon, grammar, cognition, perception, and communication, which eventually gives rise to a coherent language behaviour.

As mentioned in the beginning, the emergentist framework comprises various mechanisms that have been proposed to account for how children learn language (MacWhinney & O'Grady, 2015). The common feature of these mechanisms is that they are supposed to be domain-general and not specific to linguistic knowledge. By far, the most influential argument that non-linguistic cognitive processes could underlie children's acquisition of language knowledge comes from research on a learning mechanism referred to as statistical learning (Arciuli & von Koss Torkildsen, 2012; Frost, Armstrong, & Christiansen, 2019; Hoff, 2014). As explained in Paper I, the main assumption behind this mechanism is that language contains a wide variety of statistical patterns and children learn both lexical and grammatical aspects of their language by detecting the patterns among sounds, syllables and words and making use of them to extract the language rules (Perruchet, 2005; Saffran, Aslin, & Newport, 1996; Saffran & Wilson, 2003).

Statistical learning is not a unitary construct and includes different learning processes (Thiessen, 2017; Thiessen & Erickson, 2015). Bootstrapping mechanisms, which may help us better understand the nature of parallel learning across vocabulary and grammar domains, have been suggested to be one of the learning processes compatible with the accounts of statistical (distributional) learning (Hohle, 2009). Relatively few studies have assessed the possible bootstrapping mechanisms underpinning the association between lexicon and grammar in a longitudinal design, and the results are mixed. Some of these studies have provided evidence for both lexical and syntactic bootstrapping (Dionne, Dale, Boivin, & Plomin, 2003; Moyle, Weismer, Evans, & Lindstrom, 2007) and some found no evidence for either of them (Hoff, Quinn, & Giguere, 2018). Therefore, Paper I addressed this issue and further examined whether FR status had an impact on the potential cross-domain relations.

2.4 Oral language skills in preschool children with FR of dyslexia

As mentioned in section 2.2, it has long been known that dyslexia often runs in families. This finding has initiated numerous studies, which have followed the developmental progress of FR children from the early preschool years onward. Conducting the first prospective study of familial dyslexia, Scarborough (1990, 1991) documented that in comparison with FR non-dyslexic and NoFR children, FR children who went on to develop dyslexia at age 8 had deficiencies to varying degrees in their lexical and syntactic skills between ages 2;6 and 5 years. Several prospective family studies across languages reported results comparable to those of Scarborough (e.g., Carroll et al., 2014; Elbro et al., 1998; Snowling et al., 2019; Torppa et al., 2010; van Bergen et al., 2014; van Viersen et al., 2017). On the other hand, studies with two comparison groups only, namely, FR children vs. NoFR children, reported findings indicating a range of oral language skills in children with FR as a group in the preschool years. That is, while some studies found group mean differences that were significant, other studies found that oral language skills in FR children were not significantly different from those of the typically developing controls.

For example, Koster et al. (2005) found that as early as 17 months of age, there were significant reductions in total vocabulary size and syntactic complexity in Dutch FR children compared to their NoFR peers. However, another Dutch study with FR children, which also examined early vocabulary development at 17, 18, 19-20, 23, 29, and 35 months found that NoFR group had significantly larger vocabularies than FR children only at 19-20 months of age. There were otherwise no significant group differences between 17 and 35 months (Chen, Wijnen, Koster, & Schnack, 2017). Similarly, in a Finnish study, NoFR children had a slightly higher, but non-significant, total word production than FR children at age 18 months (Lyytinen et al., 2004). Several other studies focusing on early lexical and grammatical skills in FR children (approx. 18-31 months) also reported results in favour of the NoFR group, though the observed differences did not always reach the significance level (e.g., de Bree, Zamuner, & Wijnen, 2014; Kerkhoff, de Bree, de Klerk, & Wijnen, 2013; von Koss Torkildsen, Syversen, Simonsen, Moen, & Lindgren, 2007).

A recent study by van Viersen et al. (2018) showed that although NoFR children obtained higher mean scores than FR children, the difference between the groups was nonsignificant in both expressive syntax at age 4;6, and in expressive vocabulary at ages 4;6, 9 and 12 years. Contrary to this pattern of results, Lyytinen and Lyytinen (2004) reported vocabulary delays and deficits in inflectional morphology in Finnish FR children, which seemed to increase with age. Despite performing less well on the measures of vocabulary and inflections when tested at 2, 2;6, 3;6 and 5 years, the FR group did not differ from the NoFR group significantly at the first two assessment points. A significant group level difference was first observed at age 3;6 and it was still present at 5 years, suggesting that oral language differences between groups were more evident at later ages.

Taken together, the overview of studies above indicates that FR children as a group may have difficulties in the development of their lexical and grammatical skills. However, the severity of these difficulties and the ages of children when such difficulties were detected apparently vary from study to study. A number of possible reasons for the discrepancy between results were discussed in the articles constituting the current thesis. One of those factors, namely, the sample variation, requires additional attention though. As discussed below, it has direct bearings on the conclusions regarding the overall effect of FR status on oral language development. It also affects the interpretation of the potential implications that the language-related findings may have for educational practice, as will be elucidated in section 2.5.

2.4.1 FR status as a contributing factor to oral language difficulties

Multiple deficit models (Pennington, 2006; van Bergen et al., 2014) argue that although FR clearly elevates the odds of developing dyslexia, genetic and/or environmental risk and protective factors operate probabilistically. Consequently, not all children with FR end up with dyslexia at school age. In line with this, Snowling and Melby-Lervåg (2016) reported in their meta-analysis that the mean prevalence of dyslexia in at-risk children is 45%. This suggests that the relatively poorer performance of the FR group on language tests might reflect, to a greater degree, the performance of those within the group, who will ultimately develop dyslexia. In other words, the influence of FR status on oral skills detected in studies including comparisons only between the binary categories, FR vs. NoFR, might be more related to the reading outcomes (dyslexic vs. non-dyslexic) of children rather than their FR status.

For example, examining the vocabulary development of FR children between 17 and 35 months and its relation to dyslexia status at age 8 years, van Viersen et al. (2017) reported that FR dyslexic children had significantly lower scores in vocabulary than FR non-dyslexic and control children. The latter two groups did not differ in their vocabulary skills, leading the authors to argue that early deficits in vocabulary are associated with dyslexia status rather than with FR. This point is important to bear in mind when attempting to ascribe certain findings to the possible effect of FR status.

Another aspect of FR samples that should be taken into account when considering the role of FR in oral language development has to do with the well-recognised comorbidity between dyslexia and DLD (Bishop & Snowling, 2004; Hulme & Snowling, 2009). Based on their review of FR studies, Snowling and Melby-Lervåg (2016) point out that the majority of these studies fail to control for confounding variables, such as the possibility of comorbid conditions in the sample. In particular, they highlight the case of DLD, as it may obviously contribute to results of moderate to severe difficulties in the language domains, including vocabulary and grammar. For example, a Dutch study conducted by van Alphen et al. (2004) compared the grammatical skills of FR children to that of age-matched FR controls and children with DLD at 19 months, 25 months, and 3;3 years. Their results showed that despite performing better than children with DLD, compared to controls, FR children underperformed on tasks tapping perception and production of grammatical morphology at all assessment points, suggesting a position for FR children's grammatical performance in-between that of the NoFR and DLD children. However, within the FR sample of van Alphen et al.'s (2004) study there was a large amount of variability, implying that some of FR children may have had comorbid DLD.

In a similar vein, Nash et al. (2013) compared the oral language skills of English-speaking FR children to those of children with DLD and typically developing controls at ages 3;6 and 4;6 years. When the whole FR sample was considered, the children showed a broad range of language difficulties. However, further analysis revealed that one third of the FR group had indeed comorbid DLD, that is, they scored poorly not only in the phonological domain but also across multiple domains of oral language, including vocabulary and grammar. When these children were removed from the sample, the FR-only group showed a much more circumscribed pattern of impairment on tasks assessing phonological skills. Nash et al. (2013) concluded that a family history of dyslexia carries an increased risk for DLD. They further highlighted that these two conditions show a high incidence of phonological deficits, which appear to be a shared proximal risk factor for developing a reading disorder. Below, I will consider the ways in which the nature of the reading disorders differs according to the type of language problems (phonological and/or non-phonological) in FR children. However, before moving onto that section, a brief overview of language development in those with DLD is provided, as it is relevant not only for the discussion of potential reading problems in FR children, but also for the issue of predicting later language outcomes from earlier skills.

2.4.2 Development of oral language skills in preschool children with DLD

As stated earlier, for most children language acquisition seems to be fast and effortless occurring nearly in a stage-like fashion. Yet, it is also the case that there exists a wide range of individual differences in all aspects and stages of language development (Kidd & Donnelly, 2019), from the timing of first words produced and the subsequent rate of growth in the area of grammar to variation in the skills that underpin successful language acquisition such as sensitivity to statistical patterns in the language (Norbury, 2019). Particularly in the early preschool period, development of oral language skills is highly variable such that many children with late language emergence spontaneously grow out of their early delays (Reilly et al., 2010; Rescorla, 2011; Rice, Taylor, & Zubrick, 2008; Ukoumunne et al., 2012). That said, findings from longitudinal research also suggest that developmental trajectories of language appear to become more stable between the ages of 4 to 6 years (Klem, Hagtvet, Hulme, & Gustafsson, 2016). Alongside this, children who reach 5 years of age with poor language have been reported to be less likely to catch up with their typically developing peers, suggesting that it is around this age that DLD can be identified more reliably in children (Beitchman & Brownlie, 2014; Johnson, Beitchman, & Brownlie, 2010; Tomblin, Zhang, Buckwalter, & O'Brien, 2003).

As with other developmental disorders, in the majority of cases, DLD is not a distinct disorder, but rather the extreme end of a normal distribution of language ability. It is likely to be influenced by multiple genetic and environmental factors of small effect (Bishop, 2009). DLD is generally characterized by problems in the use of language structure (phonology, semantics, morphology, and syntax) and the effective use of language in different social contexts, i.e., pragmatics (Gooch, Sears, Maydew, Vamvakas, & Norbury, 2019). The clinical manifestations can be varied such that some children may have obvious difficulties in understanding as well as producing language; others may understand adequately but have problems formulating utterances. There may be limitations of vocabulary and/or impairments in producing sequences of speech sounds. A more common pattern is for young children with DLD to appear immature both in mastery of phonological skills and in the correct use of grammar (Bishop, 2003a), which in turn place them at higher risk of facing reading difficulties in the school years.

It should be emphasized that although children with DLD are known to have problems mainly in the use of language structure, the particular linguistic strengths and weaknesses that they have will be quite dependent on the nature of their mother tongue. For example, some preliminary results from research with Norwegian young children with DLD show that these children have difficulties especially with the word order of sentences, when the word order does not follow the ordinary sentence structure in Norwegian grammar (i.e., *Subject Verb Object*; e.g., *Per spiste fisk.*). In other words, they seem to struggle particularly more with sentences, in which an element (e.g., adverb) comes before the subject, and therefore the verb has to move in front of the subject, as in the following sentence: *I går spiste Per fisk* (Barn med språkvansker strever unødvendig med mye, 2019). These results suggest that the nature of languages may affect the ways in which DLD manifests itself.

Children who are diagnosed with DLD were usually reported to be late talkers (LTs), with delayed expressive language not related to another condition at around age 2 years (Conti-Ramsden & Durkin, 2012). A comprehensive review of late talker literature by Rescorla (2011) highlights that the majority of LTs resolve their language difficulties by school age. However, the early language difficulties of some LTs persist into childhood and warrants a diagnosis of DLD. In addition to these language profiles with resolving and persistent difficulties, longitudinal studies have also revealed that a substantial number of children show emerging language difficulties. That is, children who were not initially classified as LTs go on to display language difficulties at a later time point in childhood (Dale, Price, Bishop, & Plomin, 2003; Henrichs et al., 2011; Zambrana, Pons, Eadie, & Ystrom, 2014). These findings also indicate that not all school-age children with DLD have indeed early language delay (Rescorla & Dale, 2013).

In a recent study, Snowling, Duff, Nash, and Hulme (2016) examined the three trajectories of language development (i.e., resolving, persisting, and emerging) in children with preschool language difficulties, children with FR of dyslexia, and controls at ages 3;9, 5;8 and 8;1 years. In this study, children in the emerging group had language scores in the normal range at age 3;9 years. However, they showed a substantial decline by age 8;1 and performed more poorly than the resolving group and similarly to the persisting group on all language measures. Notably, there were more children who had a family history of dyslexia in this group. Based on this finding, Snowling et al. (2016) argue that emerging language difficulties might be difficult to detect early on; however, a familial risk of dyslexia might prove to be a useful risk indicator.

Importantly, Snowling et al.’s (2016) study also examined the literacy outcomes for each DLD trajectory. The resolving group performed at the same level as the typical children on all literacy-related measures, suggesting that when preschool language difficulties have resolved around time of formal reading instruction, the literacy outcome is generally good. This result is consistent with the critical age hypothesis, according to which it is only when language difficulties are present at time of reading instruction that they have adverse effects on reading development (Bishop & Adams, 1990; Stothard, Snowling, Bishop, Chipchase, & Kaplan, 1998). The persisting group performed poorly on all literacy-related measures, and the literacy outcomes in the emerging group were as poor as those of children with persisting DLD.

Based on these results, the authors concluded that regardless of whether their language disorder emerges early or late, children whose language difficulties persist to the point of formal literacy instruction frequently experience reading problems. Snowling et al.’s (2016) study clearly points out that it is important to consider FR children’s longer-term oral language outcomes, particularly around the time of school entry, as some of these children may have emerging DLD later in development. To our knowledge, the only empirical study that has directly explored this issue in an FR sample is that of Snowling et al. (2016), and therefore, more research is warranted. In a similar vein, research focusing on language development in LTs with a history of familial dyslexia has been limited thus far. Both of these issues have been addressed in Paper II.

2.5 The role of oral language skills in reading development

Our review thus far makes clear that reading problems are strongly related to underlying difficulties with language development and that children who come to school with weak language skills are much more likely to develop reading difficulties than their age peers with typical language. The Simple View of Reading (Gough & Tunmer, 1986; Hoover & Gough, 1990) provides a useful framework for understanding why children might fail to learn to read with understanding. According to the Simple View, reading comprehension is the product of correlated, but separable two sets of skills: decoding and linguistic comprehension. Decoding can be broadly defined as the ability to identify words in print and linguistic comprehension as the ability to understand spoken language (Nation, 2019). In the Simple View of Reading, both of these components are required for skilled reading, and neither alone is sufficient. This view further posits that the relative contribution of these two skills will change during the course of development. Early on, reading comprehension is highly constrained by limitations in decoding. However, as children get older and decoding skills increase, the correlation between linguistic comprehension and reading comprehension becomes stronger. This implies that once a level of decoding mastery has been achieved, reading comprehension is ultimately constrained by how well the child understands spoken language (Nation, 2019).

Recent research has provided robust evidence for the central tenet of the Simple View that the variations in reading comprehension can be explained by decoding and linguistic comprehension (Hjetland et al., 2019; Lervåg, Hulme, & Melby-Lervåg, 2018). For example, Lervåg et al. (2018) traced a sample of 198 Norwegian children from age 7;6 years to 11;6 years, as children learned to read. In support of The Simple View of Reading, the model including latent variables of listening comprehension and decoding, together with their interaction effects accounted for almost all (96%) of the variance in reading comprehension at age 7;6 years.

Although correlated, decoding and linguistic comprehension are two distinct skills influenced by different underlying cognitive and linguistic factors (Oakhill, Cain, & Bryant, 2003; Storch & Whitehurst, 2002). Research has shown that decoding proficiency depends on phonological skills, in particular, phoneme awareness and letter knowledge. On the other hand, linguistic comprehension seems to be underpinned by broader oral language skills, including vocabulary and grammar (Muter, Hulme, Snowling, & Stevenson, 2004) and verbal working memory and inference skills (Lervåg et al., 2018). This implies that there are three different profiles of poor readers: those with poor decoding, those with poor linguistic comprehension, and those with deficits in both decoding and linguistic comprehension. Based on the Simple View of Reading, Nation (2019) has provided a useful illustration (Figure 1) for classifying these distinct reading problems.

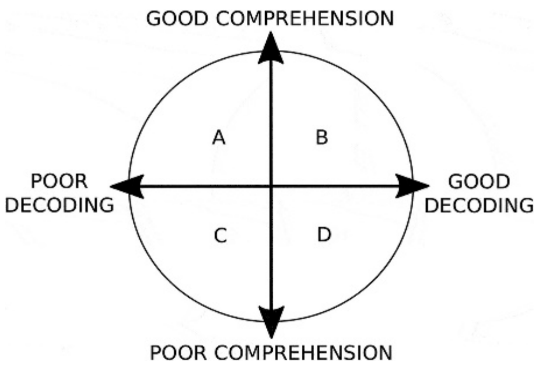

Figure 1. Classification of reading disorders within the Simple View of Reading (after Nation, 2019, p. 51)

In the figure above, children with poor decoding (i.e., dyslexia) are plotted in quadrant A, children with poor linguistic comprehension (i.e., poor comprehenders) in quadrant D, and children with poor decoding and linguistic comprehension (i.e., co-occurring dyslexia and DLD) in quadrant C. Finally, typical readers are placed in quadrant B (Nation, 2019). There are two points to be mentioned here, though. The first is that due to the high heterogeneity in DLD, some of these children fall on a continuum of skills with dyslexia, while others may show language profile, which resembles to that of 'poor comprehenders' (Snowling, 2011). The other point is that although 'poor comprehenders' usually have weak oral language skills, for most of these children their language difficulties are not severe enough for them to be diagnosed as having DLD (Snowling & Hulme, 2012a). These points suggest that the relationship between the three reading disorder profiles and language difficulties underlying them is not clear-cut, but quite complex.

However, a model proposed by Bishop and Snowling (2004) may help better understand this relationship. In their model, Bishop and Snowling (2004) argue that reading disorders are associated with two separable dimensions of language: phonological and non-phonological skills (including vocabulary and grammar). Therefore, "it is important to distinguish children with relatively pure phonologically based reading problems from those with more global language impairments" (Bishop & Snowling, 2004, p. 862). According to this two-dimensional model, children in quadrant A in Figure 1 have poor phonological skills but average nonphonological skills, children in quadrant D have average phonological but poor nonphonological language skills, and children in quadrant C have a double deficit. This suggests that children who enter school with poorly developed phonological skills are at risk of decoding difficulties, while children with broader language difficulties are at risk of reading comprehension problems. Children with double deficit are at risk of experiencing both (Snowling, & Hulme, 2015).

In short, the two-dimensional model by Bishop and Snowling (2004) points out the usefulness of making a distinction between phonological and nonphonological aspects of language, as they are respectively connected with decoding and comprehension aspects of reading. This distinction is also important because it has direct implications for screening, early identification and intervention. Bishop and Snowling (2004) recommend that in the assessment of phonological dimension of language, tasks such as nonword repetition that directly taps phonological skills should be included. This is in line with research evidence indicating that processing of nonwords is particularly difficult for those with decoding problems (Rack, Snowling, & Olson, 1992), and that nonword repetition skills seem to be impaired in affected and unaffected FR children to a similar degree (Snowling et al., 2003). The authors further suggest that tests of vocabulary and grammar development would be useful in measuring nonphonological skills. In line with this, tasks tapping lexical and grammatical knowledge have been used to assess children’s nonphonological skills in the current thesis.

A critical point to be mindful about the two-dimensional model is, as the authors acknowledge, that it “provides a useful framework for thinking about subtypes of reading impairment and their relation to language difficulties, but it is nevertheless an oversimplification” (Bishop & Snowling, 2004, p. 879). This is because although the quadrants in their model have been labelled with categorical terms, as in Figure 1, the underlying dimensions (i.e., phonological and nonphonological) are continuous. Therefore, as mentioned above, there will be children whose profile of deficit is midway between the categories. Likewise, it has been argued that the division between the two dimensions of language skills is somewhat artificial because a large body of evidence has shown that language subsystems are not modular, rather they are highly interactive (Snowling, 2005), as discussed in section 2.3.

Indeed, support for the potential interplay between phonological and nonphonological language skills in predicting reading development has been provided by longitudinal studies with both FR children (Hulme et al., 2015; van Viersen et al., 2018) and typical children (Hjetland et al., 2019). As expected, results from these studies showed that early oral language skills, including vocabulary and grammar, from around age 4 years had a direct effect on reading comprehension between ages 8;6 and 12 years. A finding that was less expected was that early lexical and grammatical skills had also a strong indirect effect (i.e., via early phonological skills) on the levels of word decoding between ages 5;6 and 7;6 years. It is worth noting that these studies were conducted with children acquiring different languages with orthographies varying in their degrees of transparency. Thus, the finding that early broader oral language skills contribute to decoding skills, although indirectly, appears to be universal.

In summary, both the Simple View of Reading and the two-dimensional model are productive frameworks that not only generate predictions of particular reading disorders but also have implications for the potentially effective treatments. That said, with the multifactorial models of dyslexia (section 2.1) and the dynamical approach to language development (section 2.3) in mind, it should be noted that reading acquisition is best thought as a dynamic process that draws differentially on different language skills that interact with each other in different developmental phases. Furthermore, literacy outcomes of preschool children with oral language problems will differ depending on individual differences not only in language skills, but also in cognitive skills, experiential factors (e.g., various activities that children are exposed to in the home literacy environment), and instructional factors, including the language in which they learn (Snowling, 2005). Therefore, more knowledge on the longitudinal development of oral language skills in FR children and the possible effects of home literacy environment on these skills might contribute to early identification of those who are at risk of reading failure. In a similar vein, more knowledge on the nature of these children's language difficulties may inform pathways for intervention during the preschool period and in the early school years.

3 Methodological reflections

This chapter addresses the methodological considerations that have not been fully covered in the three articles. First, descriptions of research design and sample characteristics are given in sections 3.1 and 3.2, respectively. Next, an overview of the variables and measures used in this thesis is provided in section 3.3. Further, the validity of the currents findings are discussed in section 3.4. Finally, some ethical perspectives related to the present study are considered in section 3.5.

3.1 Research design

The PhD study reported here is part of the larger on-going project The Tromsø Longitudinal Study of Dyslexia (TLD). The TLD project has been funded by the Tromsø Research Foundation and managed by Professor Trude Nergård-Nilssen. It follows the development of cognitive and linguistic skills in a group of children with FR and their peers with NoFR from age 12 months through the end of Grade 2 (age 8 years) in order to examine the early predictors of dyslexia in Norwegian. The articles included in the present thesis are based on data gathered at different time points between ages 1;6 and 6 years. I contributed to data collection as test-leader and performed the measurements when children were 3;6 years old. In addition, I assisted in planning and organizing the data collection at ages 3 and 4;6 years.

All three empirical studies in the thesis have a quantitative approach with a non-experimental longitudinal design. In longitudinal studies, characteristics of the same individuals are assessed over an extended period with repeated evaluations, which are often spread across at least several years (Anastassiou & Stylianou, 2011). Longitudinal studies are expensive in terms of both time and money, but they provide many significant advantages relative to cross-sectional studies. Their main advantage lies upon their unique ability to trace developmental trajectories and examine variations and changes over time. Furthermore, longitudinal data allow comparisons across time in the same individual or group of individuals and thus, facilitate examining the interdependency among developmental processes (Hofer & Piccinin, 2010).

Snowling and Melby-Lervåg (2016) note that longitudinal studies comparing children at family risk of dyslexia with children with no such risk have several advantages over the more standard case-control approach. For example, they are free of clinical bias because children are recruited before they enter formal reading instruction. They can also allow the identification of likely risk and protective factors in the preschool period. Snowling and Melby-Lervåg (2016) further note that although such longitudinal prediction can also be conducted using a general population sample, the FR-method is much more efficient. That is, one would not need so large samples to obtain an adequate number of children who will ultimately develop dyslexia due to high heritability of the disorder in FR samples (approximately 45%), compared to a general population sample with a rate of dyslexia at approximately 10% (Snowling & Melby-Lervåg, 2016)

Despite providing valuable information for understanding change processes in development, longitudinal observational designs also pose a number of challenges, such as the limits on inferences that can be drawn from this type of design and differences in measurement instruments used during the study. As these issues concern the validity, they will be discussed in section 3.4, which addresses the overall validity of current study results.

3.2 Sample characteristics

All the participants reported in the present thesis were drawn from the TLD project. They were recruited through advertisements in local newspapers and information brochures, which were distributed to parents when children came to the 9-month-visit at their local child health care clinic in Tromsø. Selection criteria and procedures are thoroughly described in the three articles. A detailed description of the tests employed to assess parents' cognitive and reading-related skills has been provided in Nergård-Nilssen and Hulme (2014). It should be noted that there was not any screening or matching of the children themselves on any tests. Thus, children were allocated to either FR or NoFR group according to their parent(s) performance on a composite score of standardized measures of reading fluency and spelling in addition to self-reported reading difficulties.

All parents and the participating children were monolingual Norwegian. Neither FR nor NoFR children had any known sensory or neurological conditions. They all had scored above

85 on a cognitive scale at age 2 years (Bayley, 2006). Parents did not differ in general cognitive abilities. Those in the FR group had a full IQ score of M = 117.45 (SD = 9.51), while parents in the NoFR group had a full IQ score of M = 118.89 (SD = 11.60), $F(1,71) = 0.49$, $p = 0.623$. It is worth mentioning though that IQ measures were not taken for diagnostic purposes, but used as a cut-off criterion (i.e., Full IQ score ≥ 85) in order to rule out the possibility of general learning disabilities (Nergård-Nilssen & Hulme, 2014). The NoFR parents had higher educational level compared to FR parents. However, the total household income was not affected by this difference. It should also be noted that the level of education was indeed generally high in both FR and NoFR parents (Nergård-Nilssen & Hulme, 2014). This indicates a sample that is not necessarily representative of the population and therefore discussed in the section concerning the validity of current results.

Altogether 53 children started as participants in the TLD project at age 12 months: 32 children with FR (12 girls and 20 boys) and 21 with NoFR (8 girls and 13 boys). As reported in Paper 2, there were seven drop-outs in the follow-up period, but at the same time, a few new participants were included in the TLD during that period. This also explains why the number of participants varies in the articles reported in here. Our aim was to utilize all the available data, which were relevant for the research questions addressed in the current doctoral work. In the first paper, which covers the age period between 1;6 and 6 years, we could use data from 54 children by adopting the suitable methods for dealing with missing data. In the second paper, we could include only 46 children, as our analyses were dependent on whether the child had a CDI score of expressive vocabulary at age 2 years. This was necessary to identify those who were late talkers at age 2 years. Accordingly, we used data from these 46 children at ages 2, 4;6, and 6 years and reported their development. In paper 3, we used data gathered from age 4 years onwards. There were in total 52 children with HLE data at age 4, and language data at ages 4;6 and 6 years. More details regarding participant numbers and characteristics are provided in the articles.

3.3 Measures

The language data used in this thesis were obtained through parent reports, and standardized vocabulary and grammar tests, which were administered individually in a laboratory at the university. The HLE data were based on parental questionnaire. Table 1 provides an overview of measures used in the three articles. In order to obtain better reliability, composite scores computed from the standardized values of different tasks were utilized whenever possible. It should also be noted that standardized scores were used in order to give equal weight to each score. More detailed descriptions of the measures together with their Cronbach's alpha coefficients are given in the articles.

Table 1. Overview of measures used in Studies I-III

				Studies		
Variable	Measure	Source	Age	I	II	III
Expressive vocabulary	CDI W&S	Parent report	1;6, 2;0 2;6, 3;0	X	X	
Expressive vocabulary	EVT-2	Individual assessment	3;6	X		
Expressive vocabulary	CELF-4	Individual assessment	4;6, 6;0	X	X	X
Receptive grammar	TROG-2	Individual assessment	3;6, 4;6	X	X	
Receptive grammar	CELF-4	Individual assessment	6;0		X	
Expressive grammar	CDI W&S	Parent report	1;6, 2;0 2;6, 3;0	X		
Expressive grammar	CELF-4	Individual assessment	4;6, 6;0	X	X	X
Book exposure	HLE questionnaire	Parent report	4;0			X
Interest in book reading	HLE questionnaire	Parent report	4;0			X

Note. CDI W&S = MacArthur-Bates Communicative Development Inventories: Words and Sentences (Fenson et al., 1993); EVT-2 = Expressive Vocabulary Test, 2nd edition (Williams, 2007); CELF-4 = Clinical Evaluation of Language Fundamentals, 4th edition (Semel, Wiig, & Secord, 2003); TROG-2 = Test for Reception of Grammar, 2nd edition (Bishop, 2003b); HLE = Home Literacy Environment.

3.4 Validity

The term of validity concerns the inferences that are drawn within and from the research results (Kleven, 2008). In Shadish, Cook, and Campbell (2002), this term has been used to refer to the 'approximate truth of an inference' as it is nearly impossible that all of the inferences drawn from a single study are true or that other inferences have been conclusively falsified. Importantly, the authors emphasize that validity is not a property of designs or methods because the same design may contribute to more or less valid inferences under different circumstances. Shadish et al. (2002) developed a typology, which addresses four different types of validity in quantitative studies: statistical conclusion validity, internal validity, construct validity, and external validity. Threats to these aspects of validity explain why inferences about covariance, causation, constructs and generalizations can be partly or completely wrong (Shadish et al., 2002). Below, a number of major threats to the validity of the present research findings have been discussed in light of the typology described by Shadish and colleagues.

3.4.1 Statistical conclusion validity

Statistical conclusion validity concerns the validity of inferences about the existence and size of covariation between variables (Kleven, 2008). One of the main threats to this type of validity is low statistical power. Small sample sizes are known to minimize statistical power and the likelihood of detecting significant results (Shadish et al., 2002). As highlighted in all three articles, the sample size of the current study, particularly the size of control group, is small. It follows that we were able to detect statistically significant differences only in cases where the effect sizes were fairly large. In that sense, our results could be considered conservative. That said, our risk was rather to reject null hypotheses when there existed a true difference between the groups. We therefore reported and interpreted not only tests of significance, but also estimates of effect size, which are to some extent independent of sample size.

Another factor contributing to low statistical power is missing data. We therefore used the recommended methods for handling missing data to be able to utilize all available data. In doing so, we tried to increase the statistical power in our analyses. In the first paper, multiple imputation, which is a model-based method, was used for dealing with difficulties caused by missing values. In Articles 2 and 3, an ad hoc method, available case analysis (pairwise deletion) was chosen (Pigott, 2001). Article 1 provides a detailed explanation of the missing data analysis used in that particular study. In the two other papers, the basic principle was to take advantage of all data available by using the pairwise option in the regression analyses. It should be noted though that it is not possible to use this option in MANOVA. Therefore, it was always the case that in each MANOVA analysis only the subjects with no missing values in all the measures used in that specific analysis were included. As a result, the number of cases in separate analyses varies a little due to that some measures had slightly more missing information than other measures. However, this variation was quite small in both papers. For example, in the MANOVAS of Article 2, the number of subjects varied from 42 to 43 depending on the measure(s) used. In comparison with Article 2, there was some more variation in reporting group differences in Article 3 (please see Table 2 for the exact figures of group sizes). However, this was unproblematic because the analyses concerned only one measure at a time. In the regression analyses reported in Article 3, the number of cases was always the same (i.e., 40), which guaranteed that the results were comparable with each other. Thus, we avoided the potential problem of analysing relations between several measures with different samples, which is argued to be one of the possible drawbacks when using available case analysis (Pigott, 2001).

According to Shadish et al. (2002), another important threat to statistical conclusion validity is violations of statistical test assumptions. As reported in all three articles, we first screened our data to check whether the basic assumptions for parametric tests used were met (e.g., concerning normality, unequal variances, and outliers) and described them thoroughly along with the results. In Article 1, a detailed explanation of the cross-lagged model together with the underlying assumptions and the model fit-indices is presented. With respect to the regression analyses used in Article 2, it should be noted that we restricted the number of predictors to four, thus retained the ratio between the number of subjects divided by the number of predictors to 10. This is in line with the minimum ratio suggested, among others, by Harrell (2015). Likewise, in Article 3, we included four to five independent measures in the regression analyses. This was done to retain the ratio between the numbers of subjects divided by the number of predictors to 8 or 10 depending on analysis, which is close to or in line with Harrell's (2015) suggestion mentioned above. On the other hand, we were not able to add any more measures, which could be of interest, into our regression analyses (e.g., mothers' language skills in Article 3) as it would have decreased the recommended minimum ratio considerably.

Unreliability of measures has been noted as one of the crucial factors that threatens the validity of statistical conclusions (Shadish et al., 2002). A conclusion about covariation may be inaccurate if either variable is measured unreliably. Shadish et al. state that unreliability always attenuates bivariate relationships and they recommend researchers to assess and report reliability for each measure. In line with this, we have reported the reliability scores (i.e., Cronbach's alpha coefficients) for each test used in the articles of the present thesis. An alpha coefficient = .70 is often considered as the minimum level of alpha, which is sufficient (Nunnally, 1978). However, it has also been argued that there is no exact level of acceptable or unacceptable level of alpha, as in some cases measures with (by conventional standards) low levels of alpha may still be quite useful (Schmitt, 1996). That said, measures used in the current thesis did all have alpha values above .70, except for the two composite measures of expressive grammar used at age 4;6 years.

In Article 1, a composite grammar score based on the means of standardized scores from the TROG-2 ($\alpha = .96$) and the two grammar subtests of CELF-4 (Word Structure, $\alpha = .92$ and Formulated sentences, $\alpha = .92$) was computed. The reliability for this composite score was $\alpha = .69$. In a similar vein, in Articles 2 and 3, scores from three subtests of CELF-4 (Word Structure, α= .78; Formulated Sentences, α= .94; and Recalling Sentences, α= 89) were standardized and combined into a composite score. Cronbach Alpha reliability for this composite score was .68. Although the alpha level for these two composite scores is just below .70, it should be pointed out that all of those tests included in them are highly reliable, as shown above. That said, the moderate alpha scores for the grammar composites (.69 and .68) could be considered satisfactory, as these tests are intended to tap different aspects of grammar. That is, TROG-2 measures children's grammatical comprehension by using a multiple-choice format. Word Structure measures children's knowledge of grammatical rules in a sentence–completion task. Formulated sentences measure children's ability to formulate compound and complex sentences when given grammatical (semantic and syntactic) constraints. Recalling Sentences measure children's ability to recall and reproduce sentences of varying length and syntactic complexity. Furthermore, level for alpha is known to be sensitive to the number of items included (Thorndike & Thorndike-Christ, 2014). The grammar composite scores reported in Article 1, and in Articles 2 and 3 were calculated from three items, and this may partially explain their relatively lower alpha value.

3.4.2 Internal validity

Internal validity refers to inferences about whether observed covariation between variable A and variable B reflects a true causal relationship between them (Shadish et al., 2002). To draw such an inference, the researcher must show that A preceded B in time, that A covaries with B, and that there are no other plausible explanations for the relationship between A and B. Shadish et al. argue that in longitudinal studies the problem concerning direction of causal influence (i.e., temporal precedence) between A and B can be solved to some extent as such studies permit analysing as potential causes only those variables that occurred before their possible effects. However, this does not justify the claim that A causes B, because there might be other factors and conditions explaining this causation.

Although strengthened by longitudinal design, the studies in the present thesis are correlational in nature. It is, in principle, not possible to rule out all other alternative explanations for the observed relationships and draw firm conclusions in correlational studies. In this respect, statistical control may be helpful to some extent, as it allows the researcher to control for certain confounding factors that are crucial to take into consideration (Kleven, 2008). For example, autoregressor effects were controlled in both the cross-lagged model (Article 1) and the regression models (Articles 2 and 3). Based on the general finding that the best predictor of future behaviour is often past behaviour, Burgess, Hecht, and Lonigan (2002) argue that the inclusion of autoregressor is necessary in order to examine possible explanations of individual differences in the growth of outcomes over specified developmental periods. They further argue that analyses conducted without the autoregressor suffer from important limitations because a known plausible cause has been omitted. Therefore, controlling for autoregressive effects has contributed to the internal validity of our results.

Some other important threats to internal validity that apply to the present research are selection bias and instrumentation (Shadish et al., 2002). Selection bias is related to systematic differences between participant characteristics that could account for the observed effect. Such bias is easily eliminated by random assignment in experimental designs because randomly allocated groups differ only by chance. However, randomization is not possible to realize in prospective studies of dyslexia, which recruit FR children from volunteering families. This means that FR children whose parents volunteered them to the TLD project may in some respects differ from other FR children whose parents did not volunteer. For example, in comparison with nonvolunteers, the volunteering parents might be already aware of the issue of FR. Accordingly, they might be relatively more motivated to ensure that their children receive the best opportunities available. These may have affected children' achievements on the measures reported in the present thesis to some extent.

The bias of instrumentation arises due to a change in a measuring instrument (Shadish et al., 2002). Instrumentation changes are particularly important to take into account in longitudinal designs, because statistical analyses related to longitudinal research ideally require identical measures across time points (Selig & Little, 2012). In line with this, Shadish et al. (2002) argue that researchers should avoid switching instruments during a study. This issue is of particular relevance to Article 1, which examined children's lexical and grammatical development between ages 1;6 and 6 years. In that study, we had to employ different measures because there were no available vocabulary and grammar measures in Norwegian that could be used at both early ages (i.e., 1;6, 2, 2;6, and 3 years) and later ages (i.e., 3;6, 4;6, and 6 years). However, as noted in Article 1, we tried to eliminate the bias of instrumentation by leaving out the time-window between ages 3 and 3;6 due to different measures used in these two time points. More precisely, while vocabulary and grammar were assessed by parent reports until age 3, these skills were tested individually in the university lab from age 3;6 onwards. Therefore, we decided to use the CDI reports in the early age period, and standardized language tests in the later period. By doing so, we managed to include the same or quite similar language measures in each cross-lagged panel that we examined in Article 1.

3.4.3 Construct validity

Construct validity is the validity of inferences drawn from observed indicators to abstract constructs. The extent to which the constructs of theoretical interest are successfully operationalised in the research is crucial to the issue of construct validity (Kleven, 2008). Threats to this type of validity therefore concern the correspondence between study operations and the constructs used to describe those operations (Shadish et al., 2002). The two main constructs of the current thesis, namely vocabulary and grammar, were operationalised by use of well-recognised and reliable language tasks (please see Table 1, section 3.3). Both CDI reports and standardized language tests that we used define and measure vocabulary knowledge as the total number of correct words the child could produce (expressive vocabulary) at a given time point. Likewise, grammar knowledge has been defined and measured as the total number of correct morphological and syntactical structures the child could understand (receptive grammar) and produce (expressive grammar) at a given time point. By doing so, we avoided operationalising the same constructs differently across the articles included in the present thesis. With respect to the HLE constructs in Article 3, namely book exposure and child's interest in book reading, the parental questionnaire included nine items to measure the former and four items to measure the latter construct. The extent to which these items together could cover all aspects of these two constructs might be questioned. However, it should be highlighted that the choice of each item was based on the HLE questionnaires of several oft-cited studies in the literature (e.g., Sénéchal & LeFevre, 2002; Torppa et al., 2007). This was important as we aimed to compare our results concerning these aspects of HLE to those reported in previous HLE studies.

3.4.4 External validity

External validity refers to the extent to which the results of a study can be generalised to other contexts, situations, and groups (Shadish et al., 2002). Generalisations over situations and groups mainly depend on similarities and differences between situations and groups actually studied and the situations and groups we draw our inferences about (Kleven, 2008). In this respect, the question of to what extent the sample studied in the current thesis is representative of the target population is important to consider. As mentioned earlier, the children were allocated to FR and NoFR groups based on their parents' performance on a composite score of standardized tests of reading and spelling in addition to self-reported reading difficulties. These criteria for being allocated to either FR or NoFR group are well in line with other longitudinal studies on FR of dyslexia (Nergård-Nilssen & Hulme, 2014; Snowling & Melby-Lervåg, 2016), which in turn contributes to external validity of the current results. However, as already discussed above, it was voluntary to participate in the TLD project. As noted in the articles, both FR and NoFR parents had relatively high level of education and performance

IQ, and they were interested in their children's development. With this in mind, it might be said that the FR children in this thesis might not be representative of children born at risk of dyslexia, which in turn limits the generalisability of the current findings. That the sample size in the present thesis was small has also a direct bearing on the representativeness of the sample, and thus threatens the external validity of our results. However, it is worth noting that findings from this thesis, as a whole, concur with previous similar studies with FR children, and this contributes to their external validity to a certain degree.

3.5 Ethical considerations

The TLD project was reported to the Norwegian Social Science Data Services (NSD) and Data protection officer at UiT – The Arctic University of Norway, where it was evaluated for issues related to anonymity and the processing of sensitive information. Permission to conduct the research project was obtained.

Both the TLD project and the three empirical studies included in the present thesis were carried out in accordance with the guidelines provided by the National Committee for Research Ethics in the Social Sciences and the Humanities (NESH, 2016). Given the age of the participating children, informed consent was obtained from their parents. In addition, the children were given age-appropriate information about the study. During the assessments, the children were encouraged to complete the language tasks. However, if the child seemed unmotivated or did not want to cooperate, either a break was given or the session was ended. It should also be mentioned that in the current articles, the results have been reported at the group level only, which in turn meets the requirement of anonymity.

4 Overview of the empirical studies

4.1 Article I

Title: Lexical and grammatical development in children at family risk of dyslexia from early childhood to school entry: A cross-lagged analysis

Authors: Ømur Caglar-Ryeng, Kenneth Eklund, and Trude Nergård-Nilssen

In this study, we compared the lexical and grammatical development of FR children to that of age-matched NoFR controls from age 1;6 up to school entry to gain more insight into the nature of the developmental patterns observed in these two language domains. Furthermore, we investigated whether family risk had an impact on the cross-lagged relationships between these domains over the course of the preschool years, as this issue was, to our knowledge, not examined in previous research. Fifty-four children (31 FR, 23 NoFR) were included in the analyses. Groups were assessed at seven time-points using both parental reports and standardized tests.

The study was guided by the following research questions: 1) Do the FR and NoFR children differ in terms of their lexical and grammatical growth from age 1;6 to 6 years? 2) What is the pattern of cross-domain associations between vocabulary and grammar across this period? Does FR status exert an effect on the relationship between lexical and grammatical development?

Results indicated that FR and NoFR-children had a similar development in the growth of their lexical and grammatical skills in the earlier years. However, FR group appeared to perform significantly more poorly on vocabulary at the end of the preschool period. Results showed no significant effect of FR status on the cross-lagged relations between lexical and grammatical skills, suggesting a similar developmental pattern of cross-domain associations in both groups. However, FR status seemed to have a significantly negative association with vocabulary and grammar scores at age 6 years, resulting in language outcomes in favour of NoFR children.

4.2 Article II

Title: School-entry language outcomes in late talkers with and without a family risk of dyslexia

Authors: Ømur Caglar-Ryeng, Kenneth Eklund, and Trude Nergård-Nilssen

This study tracked FR and NoFR children who were identified as late talkers (LTs) at 2 years from age 4;6 through 6 years and investigated whether FR of dyslexia and late talking affected these children's language development. It also aimed to examine whether FR status moderated the association between 4;6 years and 6 years vocabulary and grammar skills in children, and whether there were any interaction effects between FR status and LT status. There were 46 children included in this study: Twenty-four FR children (6 LTs at age 2), and 22 NoFR children (6 LTs at age 2).

The study addressed the following research questions: 1) What is the effect of FR and LT status on vocabulary and grammar outcomes at ages 4;6 and 6 years, respectively? Furthermore, what is the proportion of children, if any, who were at risk of DLD, at the age 6 follow-up? 2) How much of the variability in expressive vocabulary, and in receptive and expressive grammar at age 6 years is explained by children's group statuses (LT and FR) and earlier language skills assessed at the age of 4;6 years? Does FR status moderate the associations between 4;6 years and 6 years language skills?

Results showed that the main effect of LT status on language skills was significant at both 4;6 and 6 years. The ANOVA test of between-subject effects indicated that LTs scored significantly lower in expressive grammar at both ages compared to NoLTs, but not in expressive vocabulary or receptive grammar. FR status had a main effect on language skills at age 6 years only. The test of between-subject effects revealed that in comparison with NoFR children, FR children had significantly lower scores in expressive grammar, while there were no differences between the groups in expressive vocabulary and receptive grammar. The interaction between LT and FR statuses was not significant, implying that LT status affected language skills independent of the child's FR status. Nine out of 24 children in the FR group and three out of 22 children in the NoFR group were classified as being at risk of DLD at age 6 years. Results further showed that altogether 24% of the variance in expressive vocabulary, 27% of the variance in receptive grammar, and 72% of the variance in expressive grammar at age 6 years were explained by children's group statuses (LT and FR) and earlier language skills assessed at the age of 4;6 years. FR status seemed to have a moderating effect on the association between expressive grammar at ages 4;6 and 6 years.

4.3 Article III

Title: The effects of book exposure and reading interest on oral language skills of children with and without a familial risk of dyslexia

Authors: Ømur Caglar-Ryeng, Kenneth Eklund, and Trude Nergård-Nilssen

The potential role of home literacy environment (HLE) in preschool children's language development has attracted extensive research attention. However, data on FR children's HLE are scarce and mixed. Therefore, in this longitudinal study, we examined the relationship between the two home literacy-related factors (i.e., book exposure and child's interest in reading) and language development in a sample of children with and without FR of dyslexia. More specifically, by considering whether FR status serves as a moderating factor in this relationship, we investigated to what extent home literacy practices assessed at age 4 could predict broader oral language skills (i.e., vocabulary and grammar) around the time of school entry (age 6).

Our research questions were as follows: 1) Do children with and without FR of dyslexia differ in their book exposure or interest in reading at age 4 years? 2) Does family risk, book exposure, and child's own interest in reading, respectively, have an effect on expressive vocabulary and expressive grammar at age 6 years? If so, does book exposure, and, interest in reading have different effect in children with and without FR of dyslexia? 3) In the case of an effect of book exposure or child's interest in reading on expressive vocabulary and expressive grammar at age 6 years, would this be fully mediated by the 4;6-year language skill (expressive vocabulary and expressive grammar, respectively)?

Results showed that there were no significant differences between FR and NoFR children in terms of book exposure and reading interest. Furthermore, while interest in reading did not affect vocabulary and grammar in either group, book exposure contributed to vocabulary skills only in the FR group by school entry. However, this longitudinal association was fully mediated by lexical skills at age 4;6, suggesting that book exposure has a positive indirect effect on FR children's later language development through its effect on early language.

5 General discussion

The purpose of the present research was to explore the development of lexical and grammatical skills in a cohort of Norwegian children with and without FR of dyslexia from age 1;6 to 6 years in order to gain more insight into whether and how these children differ from each other in these two language areas. To achieve this, three empirical studies were conducted. More specific and thorough discussions of the study results are provided in the respective articles and not repeated here. This chapter gives a general discussion of the main findings in regard to the overarching aim of the present thesis: ‘to examine whether and how having a FR of dyslexia exerts an effect on vocabulary and grammar development in preschool children, and whether early skills and HLE contribute to predicting individual variation in subsequent language outcomes differently depending on FR status’.

5.1 On the effects of family risk of dyslexia on vocabulary and grammar development

Across languages, studies that have contrasted FR children with NoFR children in the preschool years have reported a range of lexical and grammatical skills in FR children. While some of these studies found significant differences at the group level (e.g., Koster et al., 2005), others failed to do so (e.g., de Bree et al., 2014; van Viersen et al., 2018). Moreover, several researchers reported that the FR and NoFR children in their longitudinal studies differed significantly in terms of vocabulary and grammar skills at certain ages only and they otherwise seemed to have a similar level of knowledge in these language areas (e.g., Chen et al., 2017; Lyytinen & Lyytinen 2004). Taken together, these studies show that FR children, as a group, may have difficulties in their lexical and grammatical skills, but the severity of these difficulties and the ages of children at which such difficulties were detected vary greatly from study to study.

The findings from the three articles of the present thesis are generally in line with the pattern of results described above. Our overall findings indicated that FR children’s vocabulary and grammar skills were significantly poorer than those of NoFR children at later ages (i.e., 4;6, and 6 years) in the preschool years, but not at early ages (i.e., 1;6, 2, 2;6, 3, and 3;6 years). More precisely, in Article 1, we found that the growth of expressive vocabulary was similar in both groups of children until the age of 4;6 years. However, a significant group difference in vocabulary with a large effect size was detected at age 6 years. Article 1 further showed that although the level of growth in FR and NoFR children's grammar was similar during the observation period, the effect size between the two groups in expressive grammar was moderate at age 6 years. In line with this, results from all three articles revealed a significant interaction effect between FR status and vocabulary and grammar skills at age 6 years, suggesting that having FR of dyslexia resulted in lower mean scores in both vocabulary and grammar. Results from Article 2 and Article 3 further showed that FR children performed more poorly than their NoFR peers in both expressive vocabulary and expressive grammar at age 4;6 years as well as at 6 years. While the effect sizes between the groups were moderate in all comparisons, it was large in expressive grammar at age 6 years. Moreover, the groups did not seem to differ significantly in receptive grammar at either ages and effect sizes between the groups were small, as reported in Article 2.

Taken together, our results showed that the potential effect of FR on expressive vocabulary and expressive grammar was evident at both 4;6 and 6 years, but large effect sizes were detected between the groups first at age 6 years, suggesting that FR children, as a group, developed poorer oral language skills than their NoFR peers towards the end of preschool period. This pattern of results appears to be broadly in line with the results reported in a study from the Jyväskylä Longitudinal Study of Dyslexia. Lyytinen and Lyytinen (2004) found that the FR and NoFR groups were similar in terms of their vocabulary and grammar skills early in development, but the differences between the groups increased with age. Our results, on the other, do not concur with those in van Viersen et al.'s (2018) study, which reported that none of the group level differences (FR vs. NoFR) in vocabulary and grammar were significant between ages 4;6 and 12 years.

Several possible reasons for the discrepancy between the results were discussed in detail in the articles of the thesis. Among these factors, sample variation is worth mentioning here as well. As noted in chapter 2, multiple deficit models (Pennington, 2006; van Bergen et al., 2014) argue that FR children are obviously at higher risk of developing dyslexia; however, genetic and environmental risk and protective factors operate not deterministically, but probabilistically, which in turn makes that some children in the FR samples eventually develop dyslexia, while others turn out to be typical readers. Empirical evidence has shown that FR children who ultimately get a diagnosis of dyslexia are the ones who often experience difficulties in vocabulary and grammar in the preschool years (Snowling & Melby-Lervåg, 2016). This means that because a proportion of the FR children reported here will probably not develop dyslexia, the overall results showing the performance of this group on the language tests might be affected, to a larger degree, by the lower scores of those who will develop dyslexia.

Furthermore, it has been argued that due to shared etiological and cognitive risk factors, some children in FR samples might also be at risk of developing DLD (Kovas & Plomin, 2007; Plomin & Kovas, 2005; Pennington, 2006), which typically manifests itself as a difficulty in acquiring lexical and grammatical skills (Leonard, 2014). As reported in Article 2, nine out of 24 children in the FR group, compared to three out of 22 in the NoFR group, were found to be at risk of DLD at age 6 years. Therefore, it is probably the lower performance of these children, which pulled down the mean scores of the FR group in vocabulary and grammar at ages 4;6 and 6 years. In summary, these points emphasize that when attempting to ascribe results showing poor skills in vocabulary and grammar to the potential effect of FR, it is important to bear in mind the heterogeneity of FR samples, that is, what the status of FR indeed encompasses.

This said, however, the results of the current thesis outlined above clearly indicate that nearly 40% of these children born at risk of dyslexia (i.e., 9 out of 24 FR children) come to school with below-average oral language skills. Findings from earlier research suggest that development of language skills become more stable between the ages of 4 to 6 years and children who reach 5 years of age with poor oral language are less likely to catch up with their typically developing peers (Johnson et al., 2010; Klem et al., 2016; Tomblin et al., 2003). Therefore, there are reasons to believe that the language difficulties of these nine children with FR may persist into school age and lead to a diagnosis of DLD. Moreover, it is noteworthy that of these nine FR children four were LTs whose language difficulties were not resolved by school age, whereas the remainder were not LTs, but turned out to have language skills 1SD below the average at age 6 years. As mentioned in chapter 2, the critical age hypothesis (Bishop & Adams, 1990; Stothard et al., 1998) and previous research findings (Snowling et al., 2016) suggest that regardless of whether language difficulties emerge early or late, it is only when those difficulties are present at the time of reading instruction that they have serious adverse effects on reading development. Thus, it can be argued that poor oral skills at school entry age can have negative consequences for these FR children's reading development during the school years.

The Simple View of Reading (Gough & Tunmer, 1986; Hoover & Gough, 1990) maintains that children may fail to learn to read with understanding because they may have problems in decoding skills, or in linguistic comprehension skills, or in both. Linguistic comprehension is underpinned, among other skills, by broader oral language, including vocabulary and grammar (Muter et al., 2004); hence, the FR children with poor oral skills in the current research might experience reading problems due to deficit in their linguistic comprehension. In line with this, the two-dimensional model by Bishop and Snowling (2004) suggests that poor broader oral language skills place these children at particular risk of reading comprehension problems. It should be noted that longitudinal studies across languages have provided much evidence for a direct link between early vocabulary and grammar skills and later reading comprehension, but importantly, they have also found that these two language skills have a strong, though indirect, effect of on the development of later decoding skills in children with both FR and NoFR of dyslexia (Hjetland et al., 2019; Hulme et al., 2015; van Viersen et al., 2018). Based on the points above, our results together suggest that the FR children in the current study, who enter the primary school with difficulties in oral language skills, are likely to face problems in both decoding and reading comprehension skills, to varying degrees though.

5.2 On the predictive relations between early vocabulary and grammar skills and later language outcomes

In chapter 2, language acquisition process has been described as a complex dynamic system including many components, of which properties change continuously (van Geert, 2010). The change in the language components is argued to be due to their recursive interactions with each other and with the external environment (Evans, 2007). Accordingly, this dynamic interplay suggests that vocabulary may affect the development of grammar positively and vice versa (van Geert, 2010). In line with this, results from Article 1 revealed moderate to strong correlations between lexical and grammatical skills from age 1;6 to 6 years in both FR and NoFR groups. This suggests that these two skills develop in tandem not only in the early years of language development, as reported in previous research (e.g., Bates & Goodman, 2001; Braginsky, Yurovsky, Marchman, & Frank, 2015), but also at later ages (i.e., 4;6 and 6 years).

Regarding the nature of the longitudinal lexical and grammatical relationships, cross-lagged analyses in Article 1 provided evidence for both lexical bootstrapping (Dale et al., 2000) and syntactic bootstrapping (Gleitman, 1990; Naigles & Swensen, 2007) at different ages though. An important point to note here is that FR status did not seem to have a moderating effect on any of the cross-lagged relations, implying that bootstrapping effects were similar in children’s vocabulary and grammar development regardless of whether they had a genetic risk for dyslexia or not. Furthermore, our cross-lagged analyses are also in support of the view that earlier developments in one domain may provide the foundation for subsequent developments in other domains (Hoff, 2014). Similarly, our findings from Articles 2 and 3 provided some evidence for the autoregressive effects of vocabulary and grammar knowledge on later development in these language areas, a result which is in line with the argument that the next state of a dynamic system (e.g., language acquisition process) emerges as a result of its preceding state (van Geert, 2010).

On the other hand, further results from Article 1 pointed towards relatively weaker and partly non-significant associations between vocabulary and grammar skills when measures from the earlier age range (i.e., 1;6 to 3 years) were correlated with measures from the later age range (i.e., 3;6 to 6 years). As mentioned before, development of oral language skills is known to be highly variable particularly in the early preschool period (Reilly et al., 2010; Rescorla 2011; Ukoumunne et al., 2012), although it becomes more stable with age (Klem et al., 2016). Therefore, the current results concerning long-term correlation between vocabulary and grammar skills might be to some extent due to the high level of individual variation in children’s early language skills.

Regarding the extent to which earlier vocabulary and grammar skills (age 4;6 years) and HLE could predict the variation in subsequent language outcomes (age 6 years), results from Articles 2 and 3 revealed that some of the variance in these language outcomes remained unexplained. However, as discussed in Article 2, our models included language skills assessed after age 4 years and indeed seemed to explain more variance in the outcome measures, compared to the studies, of which prediction models included language skills assessed before the age of three years (e.g., Ghassabian et al., 2014; Henrichs et al., 2011).

Prediction models in Article 3 also showed that high book exposure (an aspect of HLE) contributed to vocabulary skills at age 6 years, but this was the case only in the FR group. However, further analyses revealed that the effect of book exposure on FR children's later vocabulary skills (age 6 years) was fully mediated by children's lexical knowledge at age 4;6 years. A possible explanation might be that children with better early vocabulary skills elicit a richer HLE, which can indirectly affect later vocabulary skills. This type of explanation is in line with the arguments related to how genetic and environmental factors may act together in the development of children's language and literacy skills (Pennington & Peterson, 2015). Particularly, the view of active Gene-Environment correlation (Scarr & McCartney, 1983, cited in Peterson & Pennington, 2015), which asserts that children actively select different types of environment for themselves and children's individual characteristics affect these selections, might help better understand the current results.

6 Conclusions and implications

Taken together, the results of the present thesis showed that FR children, as a group, had poorer oral language skills than their NoFR peers, though not early in development but towards the end of the preschool period. Notably, a proportion of the FR children appeared to develop late emerging language difficulties by school entry, despite having typical expressive vocabulary skills at age 2 years. This was not observed in the NoFR group. Thus, our results suggest that having FR may put children at increased risk for DLD. A corollary of these findings is that FR children with poor oral language skills at school entry age might be at risk of having problems in reading comprehension in addition to their familial risk for developing dyslexia. The current results together highlight the importance of having a continuous focus on the development of oral language skills in FR children, particularly in the years preceding formal schooling. This may in turn contribute to early identification of those who are at high risk of reading problems and provision of timely intervention. As noted earlier, despite complying with previous research, our results are based on a rather small sample of children, and thus should be interpreted with caution. Some of the research questions in the articles constituting this thesis were not addressed before. These novel findings need to be replicated in future studies with larger samples.

Regarding the issue of intervention, it has been recommended that FR children with language difficulties should receive appropriate support during the preschool period, including speech and language therapy. In addition, parental assistance with the development of children's preliteracy skills might be helpful. As for the type of support after school entry, careful monitoring of these children throughout the early school years can be advised. This is due to the fact that a proportion of these at-risk children may make a good start in learning to read but fail later as literacy demands increase (Snowling & Hulme, 2015). Additionally, intervention programmes targeted to improve phonological skills in at-risk children can be effective in promoting decoding skills, while early intervention targeting vocabulary and grammar skills can have positive effects on linguistic comprehension skills, which may in turn contribute to the development of reading comprehension skills (Snowling & Hulme, 2012b).

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Empirical studies

Study I

Caglar-Ryeng, Ø., Eklund, K., & Nergård-Nilssen, T. (2019). Lexical and grammatical development in children at family risk of dyslexia from early childhood to school entry: a cross-lagged analysis. *Journal of Child Language, 46*(6), 1102-1126.

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ARTICLE

Lexical and grammatical development in children at family risk of dyslexia from early childhood to school entry: a cross-lagged analysis

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Abstract

The aim of this study was to examine (a) the development of vocabulary and grammar in children with family-risk (FR) of dyslexia and their peers with no such risk (NoFR) between ages 1;6 and 6;0, and (b) whether FR-status exerted an effect on the direction of temporal relationships between these two constructs. Groups were assessed at seven time-points using standardised tests and parental reports. Results indicated that although FR and NoFR children had a similar development in the earlier years, the FR group appeared to perform significantly more poorly on vocabulary at the end of the preschool period. Results showed no significant effect of FR status on the cross-lagged relations between lexical and grammatical skills, suggesting a similar developmental pattern of cross-domain relations in both groups. However, FR status seemed to have a significantly negative association with vocabulary and grammar scores at age 6;0, resulting in language outcomes in favour of NoFR children.

Keywords: dyslexia; vocabulary; grammar; lexical bootstrapping; syntactic bootstrapping

Introduction

It has long been known that dyslexia runs in families, and the consensus view is that dyslexia is a multifactorial disorder with a complex interaction of genetic factors with environmental influences (Snowling & Melby-Lervåg, 2016; van Bergen, van der Leij, & de Jong, 2014). Over the past thirty years, research on children with familial risk of dyslexia (FR) has shown that FR children are at heightened risk of experiencing reading difficulties (e.g., Snowling, Gallagher, & Frith, 2003; Torppa, Lyytinen, Erskine, Eklund, & Lyytinen, 2010). A recent review by Snowling and Melby-Lervåg (2016) has furthermore reported that the course of language development might differ between these children and their peers without family risk of dyslexia (NoFR) in the preschool years. Although FR children have impairments primarily in the phonological domain, these children, as a group, tend to score lower than their NoFR peers on tasks assessing wider oral language skills, including vocabulary and grammar (e.g., Gallagher, Frith, & Snowling, 2000; van Viersen *et al.*, 2018).

The preschool language problems of children with dyslexia show some similarities to those detected in children with developmental language disorder (DLD, which has replaced the term Specific Language Impairment; Bishop & Snowling, 2004; Bishop *et al.*, 2017). Recently, it has been reported that nearly one-third of preschool children with FR met the criteria for a diagnosis of DLD. This demonstrates the importance of recognising the continuities between reading and language disorders and keeping an eye on FR children's language development from early on (Nash, Hulme, Gooch, & Snowling, 2013). A great deal of evidence suggests that reading (and spelling) disorders are strongly associated with underlying delays and difficulties with language development (Snowling & Hulme, 2012). It is therefore particularly important to capture the early development of vocabulary and grammar and the interplay between them in children who have a family history of dyslexia. The current study compared the lexical and grammatical development of FR children to that of age-matched NoFR controls from age 1;6 up to school entry to gain more insight into the nature of the developmental patterns observed in these two language domains. To our knowledge, this is the first longitudinal study to examine whether family risk has an impact on the cross-lagged relationships between these domains over the course of the preschool years.

The role of broader language skills in literacy development

Developmental dyslexia is a learning disorder which mainly affects the ability of reading and spelling. An underlying weakness in phonological (speech sound) processing has been suggested to be the primary cause of word-level reading impairments in dyslexia (Snowling & Hulme, 2012). Studies on reading development carried out in alphabetical languages have provided converging evidence that phoneme awareness and letter knowledge are two of the most crucial predictors of variation in children's learning to decode print, both in irregular (e.g., English) and regular (e.g., Norwegian) orthographies (Lervåg, Bråten, & Hulme, 2009; Thompson *et al.*, 2015). However, the ultimate goal of reading is to understand written text, which requires access to the meanings of words and higher-level processes such as sentence integration and inferencing (Snowling & Hulme, 2012). In early development, comprehension strongly depends on word decoding skills (Hulme, Nash, Gooch, Lervåg, & Snowling, 2015). When children get older, however, the correlation between reading comprehension and decoding skills tends to decrease, whereas the correlation between reading comprehension and oral language skills, including vocabulary and grammar, increases (Hulme *et al.*, 2015). Therefore, literacy development depends not only on the phonological skills but also on the broader oral language skills that children bring to the task of reading.

Recent longitudinal studies of FR children have confirmed the essential role of early language skills as a foundation for literacy development across languages (e.g., Dutch: van Viersen *et al.*, 2018; English: Carroll, Mundy, & Cunningham, 2014; Hulme *et al.*, 2015; Snowling, Gooch, McArthur, & Hulme, 2018; Finnish: Torppa *et al.*, 2010). In their study with English-speaking FR children, Hulme *et al.* (2015) demonstrated that language skills at age 3;6 predicted the preliteracy skills (i.e., phoneme awareness, rapid naming, and letter–sound knowledge) at age 4;6, which in turn predicted word-level literacy at age 5;6. Interestingly, they also found that oral language skills assessed at age 3;6 had a direct influence on reading comprehension at age 8;6, leading the authors to argue that these skills might have a causal effect on reading comprehension development. Van Viersen *et al.* (2018) reported similar findings from Dutch-speaking FR children, showing that the two pathways toward reading comprehension, that is, one through preliteracy skills and word decoding and the other through later language abilities, both built on early oral language skills.

In summary, studies conducted across languages show that reading (and spelling) disorders are strongly associated with underlying delays and difficulties with language development (Hulme *et al.*, 2015). Deficient skills in the phoneme awareness and letter knowledge of FR children are well documented in the literature (Snowling & Melby-Lervåg, 2016). However, the early lexical and grammatical skills of FR children are relatively less examined, and therefore it is of interest to observe the development of these skills from early on in this group of children. Moreover, to our knowledge, Norwegian-speaking preschoolers with FR have not been previously studied on this topic. By doing this, before the onset of formal schooling, we could determine whether these children may be at higher risk of facing reading difficulties, not only in decoding but also in reading comprehension.

Lexical and grammatical development in FR children

Prospective studies of English-speaking children carried out by Snowling and colleagues (2003), and by Carroll *et al.* (2014) show that FR children who go on to develop dyslexia had lower vocabulary and grammar scores at ages 4;0 and 6;0 compared to both unaffected FR children and NoFR children (i.e., the control group). Likewise, van Viersen *et al.* (2017) reported that unaffected FR children and NoFR children had the same levels of receptive and expressive vocabulary skills between ages 17 and 35 months. The overall vocabulary of affected FR children (i.e., FR children with dyslexia) was poorer compared to both groups.

On the other hand, studies that have contrasted FR children with NoFR children in the preschool years evidence a range of broader language skills in FR children with group means, which are not always significantly different from the typically developing controls. For example, in a Finnish family risk study by Lyytinen *et al.* (2004), NoFR children had a slightly higher, but non-significant, total word production than FR children at age 18 months, whereas a Dutch study by Koster *et al.* (2005) revealed a significant difference between the FR and NoFR groups for total word production at 17 months. Another Dutch family study reported that the NoFR group had significantly larger vocabularies than FR children only at 19–20 months, with no significant group differences otherwise detected between 17 months and age 2;11 (Chen, Wijnen, Koster, & Schnack, 2017). Further, the English-speaking FR children in the Nash *et al.* (2013) study performed significantly worse than their NoFR peers on a grammatical inflections test at age 3;6, but when tested at age 4;6, the group-level differences were no longer significant. In contrast, Lyytinen and Lyytinen (2004) reported vocabulary delays and deficits in inflectional morphology, which became more evident with increasing age, in Finnish FR children. Although the FR group did not differ from the NoFR group significantly at the first two assessment points (ages 2;0 and 2;6), a significant group-level difference was observed at age 3;6 and remained at age 5;0.

Overall, these results indicate that the onset and persistence of language problems in FR children vary across studies. The variation in oral language skills between FR samples may have several reasons. As mentioned earlier, a line of research has established that there is a large overlap between dyslexia and DLD, probably due to shared cognitive and aetiological risk factors influencing both disorders (e.g., Catts, Adlof, Hogan, & Weismer, 2005; Nash *et al.*, 2013; Snowling & Hulme, 2012). Bishop and Snowling (2004) proposed a two-dimensional model in which phonological and non-phonological (i.e., semantics, syntax, discourse) skills are separated. The authors hypothesise that phonological deficits underlie both dyslexia and DLD, but children with DLD would also show deficits in broader oral language skills. Along these lines, Snowling and Melby-Lervåg (2016) argue that the proportion of children with language impairments in FR samples could explain group-level differences in linguistic domains to varying degrees.

Furthermore, a recent longitudinal study by Snowling, Duff, Nash, and Hulme (2016) followed children who were initially classified as having either family risk for dyslexia or language impairment, from age 3;9 to age 8;1. In this study, in addition to the two groups of children, one with resolving and one with persisting language impairments, a third group was identified. The children in the third group had had late-emerging language delays detected at age 8;1. Children in this group had average oral language abilities in preschool, but developed language problems in middle childhood. Interestingly, a high proportion of these children were at family risk for dyslexia, suggesting a significant association between the late-onset trajectory and a family history of literacy problems. In a similar vein, Zambrana, Pons, Eadie, and Ystrom (2014), who followed children from ages 3;0 to 5;0, reported that children who developed late-emerging language difficulties at age 5;0 typically had a family history of reading impairments. These latter findings emphasise the importance of following FR children's language skills from the early years through to school age to track possible delays in linguistic growth.

Differences in native languages might also explain the variations in findings between studies regarding the ages at which FR and NoFR children differ in vocabulary and grammar knowledge. The children in the present study are native speakers of Norwegian, which is a Germanic language with a similar syntactic and morphological structure to English. For example, verbs are divided in two classes (regular vs. irregular) and inflected for tense, mood, and voice. The Norwegian lexicon is predominantly Germanic, but also includes loan words from other languages (Simonsen, Kristoffersen, Bleses, Wehberg, & Jørgensen, 2014). Research on the longitudinal development of lexical and grammatical skills in toddlers and young children acquiring Norwegian has been sparse (Simonsen *et al.*, 2014). Our study will partly fill this void by studying vocabulary and grammar knowledge in NoFR and FR children, respectively, at ages 1;6, 2;0, 2;6, 3;0, 3;6, 4;6, and 6;0. It will furthermore add to earlier English and Finnish studies by investigating the development of these skills in the Norwegian sample of FR children. And finally, by making the most of the longitudinal nature of the data, this study was taken to examine the possible interaction between lexicon and grammar across time, and whether FR status has an impact on the cross-lagged relations between the two constructs.

Links between vocabulary and grammar in the preschool years

Children typically produce their first words somewhere at age 10–12 months, and start combining words at age 16–20 months (Bates & Goodman, 2001). Although most children master the essential grammatical structures of their native language by ages 3;0 to 3;6, some specific properties of grammar, and lexicon–syntax interactions, continue to develop through the preschool years (Bates & Goodman, 2001). A central question prompted by this description is whether and how vocabulary and grammar relate to one another across development. Earlier studies have provided empirical evidence that there is a strong and positive correlation between measures of lexical and grammatical skills in early language acquisition (i.e., up to ages 2;6–3;0). In a seminal longitudinal study of English-speaking toddlers, Bates, Bretherton, and Snyder (1988) found a correlation of .83 between vocabulary size at 20 months and grammar measured using the mean length of utterance (MLU) at 28 months, pointing to a strong interdependency between these two domains. Subsequent studies using parental reports on typically and atypically developing children (e.g., Bates & Goodman, 2001; Braginsky, Yurovsky, Marchman, & Frank, 2015; Marchman & Bates, 1994; Thordardottir, Weismer, & Evans, 2002) have corroborated these findings across various languages, lending support for the hypothesis that the emergence of syntactic and morphological structures in early language development depends on the extent of expressive vocabulary (i.e., the critical mass hypothesis; Marchman & Bates, 1994).

The temporal ordering that early lexical development occurs prior to the onset of grammatical constructions is often accounted for by a mechanism referred to as lexical bootstrapping (e.g., Dale, Dionne, Eley, & Plomin, 2000). According to this account, a sufficient number of content words is the necessary foundation to abstract the regularities and irregularities, which are required for the production of grammatical forms (Marchman, Martínez-Sussmann, & Dale, 2004). However, as with any bivariate relationship, there is also a possibility that the tight link observed between vocabulary and grammar is due to the strong influence of grammatical growth on vocabulary learning. That is, children's growing grammatical knowledge can be seen to act as a driving force behind their lexical acquisition. This process, known as syntactic bootstrapping (Gleitman, 1990; Naigles, 1990; Naigles & Swensen, 2007), suggests that children exploit morphological and syntactic cues in the linguistic input (e.g., the types of words that appear in certain parts of a sentence) to derive the meaning of novel words, and has been well documented in experiments with both infants and preschoolers (e.g., Bernal, Lidz, Millotte, & Christophe, 2007; Naigles, & Kako, 1993). The main assumption behind both the bootstrapping approaches is that there is a systematic relationship, though to varying degrees, between the properties of the lexical and the grammatical representations, and the child can detect and make use of the regularities that characterise the interaction between these two linguistic domains (Gleitman, 1990; Weissenborn & Hohle, 2001). This assumption implies that the major role of bootstrapping mechanisms is to detect structural units and properties in the language input that can serve as constraints for further learning. Hence, it has been argued that bootstrapping mechanisms indeed function as a filter between input and learning to constrain the learning mechanisms in a linguistically relevant way, and that these learning mechanisms themselves can be of a general character, and are not necessarily domain-specific, such as statistical (distributional) learning (Hohle, 2009).

Statistical learning refers to the ability to implicitly detect recurring patterns and regularities in sensory input based on their frequency, variability, distribution, and co-occurrence probability to learn higher-order structure (Erickson & Thiessen, 2015). The term 'statistical learning' was originally used to describe infants' sensitivity to the probability with which syllables co-occur, and their use this property to segment words from fluent speech (Thiessen, 2017). However, a seminal study of artificial language learning by Saffran and Wilson (2003) showed that young children could not only segment continuous speech into words, but also that they could extract syntactic rules from it. These results suggest that young children are able to move from surface structure to deeper structure as they track syllables to find words and then an underlying grammar to learn about phrasal units. Therefore, these results illustrate how learning at one level of analysis could potentially affect learning downstream (Romberg & Saffran, 2010). Research on infants with FR of dyslexia has evidenced that family risk is strongly associated with a deficit in the perception and segmentation of speech, which supports the hypothesis that phonological deficits in dyslexia have their origins in poor sensitivity to speech stimuli (Lohvansuu, Hämäläinen, Ervast, Lyytinen, & Leppänen, 2018; Snowling, Lervåg, Nash, & Hulme, 2019). In their longitudinal study, Lohvansuu *et al.* (2018) documented that atypical brain responses to speech sounds in infancy could implicate a deficient development of phonological representations that later hindered access to lexicon in at-risk children. Likewise, Snowling *et al.* (2019) showed that deficits in speech perception were related with both poor language skills and poor reading in a sample of preschoolers with FR of dyslexia. These findings suggest that deficiencies in segmenting words from continuous speech may have long-term effects on later language development in at-risk children.

As stated earlier, bootstrapping mechanisms, which are compatible with the accounts of statistical leaning, underscore the role of distributional and structural information in the input. They also postulate interfaces between different linguistic domains, which may be responsible for parallel learning (Hohle, 2009). Therefore, given the existence of correspondences between syntax and semantics, one might expect to find positive correlations between the measures assessing them. However, concurrent correlations do not provide much information about the precise nature of the longitudinal link between lexical and grammatical development (e.g., temporal ordering) and the possible bootstrapping mechanisms underpinning this association. Despite the long-standing research interest, relatively few studies have addressed the directionality of the influence between words and grammar using analytical techniques testing the contribution of each aspect of language to the other in a longitudinal design (e.g., Dionne, Dale, Boivin, & Plomin, 2003; Hoff, Quinn, & Giguere, 2018; Moyle, Weismer, Evans, & Lindstrom, 2007).

In a study of same-sex twin pairs between the ages of 2;0 and 3;0, Dionne *et al.* (2003) investigated the role of lexical and syntactic bootstrapping mechanisms and found that lexical knowledge at age 2;0 was related to grammatical level at age 3;0 (i.e., lexical bootstrapping), and that grammatical level at age 2;0 predicted lexical level at age 3;0 (i.e., syntactic bootstrapping), thus providing support for reciprocal influences between domains (i.e., bi-directional bootstrapping). Moyle *et al.* (2007) compared the lexical and grammatical growth in late-talking and control children and reported significant positive cross-domain correlations in both groups. However, in the late-talker group, there were weaker correlations between earlier grammar and later vocabulary size than between earlier vocabulary and later grammar, indicating predominantly lexical bootstrapping. Control children, on the other hand, exhibited lexical bootstrapping and syntactic bootstrapping more equally throughout the preschool years providing support for bi-directional links between the two domains. In contrast to the findings of Dionne *et al.* (2003) and Moyle *et al.* (2007), a recent longitudinal study examining vocabulary and grammar growth in Spanish–English bilingual children between ages 2;6 and 4;0 found no evidence for lexical or grammatical bootstrapping, despite the fact that the slopes of vocabulary and grammar growth were correlated within each language (Hoff *et al.*, 2018). Finding no support for bootstrapping between the domains, the authors proposed that the effects of children's language-specific input on both lexical and grammatical development in each language could account for the correlated but uncoupled growth of these two domains.

The current study

Previous research provided evidence that developmental interdependencies between vocabulary and grammar may differ in typically and atypically developing children (Moyle *et al.*, 2007). However, to our knowledge, no studies so far have examined whether FR status may have an effect on possible lexical and grammatical bootstrapping mechanisms in children with a family history of dyslexia. Utilising path analyses in MPLUS, in this study, we could separate the direct effects of the cross-lagged associations between vocabulary and grammar (lexical bootstrapping), and vice versa (syntactic bootstrapping), while taking into account the indirect effects via concurrent measures of vocabulary and grammar. To summarise, we aimed to compare the developmental trajectories of vocabulary and grammar skills in Norwegian FR and NoFR children and to explore the temporal relationship between the constructs from early years to school entry age (children in Norway start school the calendar year they turn six) by answering the following questions:

1. Do the FR and NoFR children differ in terms of their lexical and grammatical growth from age 1;6 to 6;0? It was hypothesised that we might not detect significant between-group differences in these domains because children in this study do not have a definite dyslexia status yet. Prior research suggests that since it is mainly the FR children with a later diagnosis of dyslexia who show below-average oral language skills in the preschool years, detecting significant differences at the group level might be dependent on the number of affected FR children in a given sample (van Viersen *et al.*, 2018). On the other hand, emerging evidence revealed a significant association between late-onset language problems and family risk of dyslexia (Snowling *et al.*, 2016). Thus, it was also hypothesised that group-level differences on language measures might be observed later in development (i.e., towards the end of the preschool period).
2. What is the pattern of the developmental interdependencies between lexical and grammatical domains across this period? Does FR status exert an effect on the relationships between vocabulary and grammar? Based on previous research, it was predicted that lexical bootstrapping would be observed in the earlier years of development (e.g., Marchman & Bates, 1994). However, it was also predicted that syntactic bootstrapping would be detected from approximately age 3;6 onwards, when grammatical knowledge is generally consolidated in most children. As for the prediction about the possible effect of the FR status on the associations between vocabulary and grammar development, the hypothesis is open, as to our knowledge no previous studies have explored this issue before.

Method

Participants

The 54 children reported here are the participants of the prospective Tromsø Longitudinal Study of Dyslexia. All children were monolingual Norwegian, and had no known neurological conditions. There was no difference in general cognitive ability between the FR group (mean = 105.16, SD = 8.90) and the NoFR group (mean = 108.64, SD = 9.28) ($t(51) = 1.14$, $p = .175$) at age 24 months (Bayley, 2006).

The families were recruited from the arctic region of Norway via advertisements in local newspapers and brochures at local child health clinics. The families were selected in a three-stage procedure. In stage 1, parents who volunteered to participate in the study completed a short questionnaire. The questionnaire asked whether the parent had ever experienced reading and spelling problems and whether close relatives (i.e., their own parents and siblings) had experienced such problems (on a yes/no scale). In stage 2, parents were invited to a semi-structured interview. A detailed questionnaire was mailed to the parents before the interview. Parents who reported current impairments and/or a history of reading and writing impairments were asked to give a more detailed description in the interview. In stage 3, all parents were tested on a battery of literacy tests to validate their self-reported reading and spelling abilities. Parents were also tested on a wide battery of reading-related cognitive skills (see Nergård-Nilssen & Hulme, 2014, for a more detailed description of the tests and procedures employed).

Family risk (FR) group

If one parent (or both) performed below –1 standard deviation on a composite score of standardized measures of reading fluency and spelling, and if this parent (or both) had a self-reported history of reading problems, children were allocated to the family risk group. Thirty-one children (11 girls, 20 boys) met these two criteria.

No-family risk (NoFR) group

Children whose parents performed within the normal range on standardised tests of reading fluency and spelling, and had no self-reported history of reading problems, were allocated to the No-FR group. Twenty-three children (11 girls, 12 boys) met these criteria.

Parent characteristics

Table 1 displays demographic variables and characteristics for FR and NoFR parents at the beginning of the study. NoFR parents had a significantly higher educational level compared to FR parents. The household income was however unaffected by differences in extent of education. There were no group differences in general ability (as indexed by Performance IQ). However, NoFR parents performed significantly better on verbal comprehension (WASI; Ørbeck & Sundet, 2007) compared to FR parents, which may suggest that some parents in the FR group suffer from developmental language disorder in addition to dyslexia. There were also large group differences on tests measuring decoding (word-level reading) and spelling skills in FR and NoFR parents.

Measures

Table 2 shows the vocabulary and grammar measures used in the present study at the different time-points.

Table 1. Demographic variables at the beginning of the study

	NoFR parents		FR parents					Effect size
	Mean	*SD*	*Mean*	*SD*	*t*	*df*	*p*	*Cohen's d*
Age	35.00	5.26	34.80	5.41	0.22	115	.827	0.04
Educational level	3.17	0.85	2.85	0.87	1.99	118	.049	0.37
Education after compulsory schooling	4.06	2.91	3.22	2.74	1.51	109	.133	0.29
Total household income	2.71	1.14	2.69	1.10	0.98	114	.922	0.18
Performance IQ	120.17	8.98	118.79	11.47	0.55	74	.581	0.13
Verbal Comprehension, mothers	56.66	4.72	51.32	5.56	3.17	39	.003	1.04
Verbal Comprehension, fathers	57.56	3.62	52.08	4.50	4.07	38	.000	1.34

Note. Educational level (1 = compulsary school (year 1–10); 2 = upper secondary school / high school (year 11–13); 3 = bachelor's degree; 4 = master's degree and/or PhD). Education after compulsory schooling is indexed by number of years completed after Year 10 in lower secondary school. Performance IQ and Verbal Comprehension was assessed by Wechsler Abbreviated Scale of Intelligence (WASI; Ørbeck & Sundet, 2007). Here, Verbal Comprehension is the mean raw score of Voabulary and Similarties.

Table 2. Means, standard deviations, and group comparisons of children in lexical and grammatical measures

	FR		NoFR			
	Mean	SD	Mean	SD	*t(52)*	Cohen's *d*[a]
Lexical measures						
CDI, 1;6	42.81	38.07	37.17	27.90	−0.60	0.17
CDI, 2;0	258.85	170.70	235.45	135.99	−0.53	0.15
CDI, 2;6	464.90	162.48	489.26	156.63	0.55	0.15
CDI, 3;0	581.92	111.96	603.99	85.75	0.79	0.22
EVT, 3;6	46.12	13.16	48.61	11.88	0.72	0.20
CELF, 4;6	7.58	2.20	7.57	2.50	−0.01	0.00
CELF, 6;0	10.85	2.40	12.27	1.95	2.33*	0.66
Grammatical measures						
CDI, 1;6	1.35	2.33	0.30	0.76	−2.08*	0.61
CDI, 2;0	29.08	24.76	29.33	22.74	0.04	0.01
CDI, 2;6	58.75	25.40	62.70	28.87	0.53	0.14
CDI, 3;0	86.42	29.30	88.94	23.65	0.34	0.09
TROG, 3;6	27.36	13.48	25.47	13.81	−0.50	0.14
TROG, 4;6	49.14	14.66	45.40	17.58	−0.85	0.23
CELF, 4;6	25.63	8.82	27.83	11.16	0.81	0.22
CELF, 6;0	41.76	13.62	47.46	15.52	1.43	0.40

Note. FR = family risk of dyslexia (n = 31); NoFR = no family risk of dyslexia (n = 23); SD = standard deviation; CDI = MacArthur-Bates Communicative Development Inventories (Fenson *et al.*, 1993); EVT = Expressive Vocabulary Test, 2nd edition (Williams, 2007); CELF = Clinical Evaluation of Language Fundamentals, 4th edition (Semel *et al.*, 2003); TROG = Test for Reception of Grammar, 2nd edition (Bishop, 2003).
[a] Effect size was estimated with Cohen's *d* using the pooled standard deviation of the groups; * $p < .05$.

MacArthur-Bates Communicative Development Inventories: Words and sentences (CDI W&S; Fenson *et al.*, 1993; Norwegian adaptation by Kristoffersen & Simonsen, 2012). Parents were asked to report on their child's expressive vocabulary and grammar at ages 1;6, 2;0, 2;6, and 3;0, respectively, by means of the CDI W&S form. Items marked by parents as "word produced by the child" within each of the 22 semantic categories of the *Vocabulary Checklist* were summed to yield the 'CDI: Vocabulary score'. Similarly, items marked by parents within the *Inflections Checklist* (noun plurals and past tense forms) and the *Grammatical Complexity Checklist* (42 pairs of sentences, in which one sentence is in a more complex form than the other) were summed to yield the 'CDI: Grammar score'. Raw scores were used for the CDI outcomes. Reliability for the CDI W&S scales varies between Cronbach's alpha (α) .74 and 1.00 (Kristoffersen & Simonsen, 2012).

Expressive Vocabulary Test-2 (EVT-2). The EVT-2 Form A (Williams, 2007) was used to measure children's expressive vocabulary and word retrieval at age 3;6. Here, the examiner presented the child with a picture and a stimulus question, with stimulus words arranged in order of increasing difficulty. The child responded with a one-word label, answered a specific question, or provided a word that fitted the picture. Testing was discontinued when five consecutive items had been failed. The score here was the number of correct responses. Split-half reliability for EVT-2 Form A is $\alpha = .94$ (Williams, 2007).

Test for Reception of Grammar-2 (TROG-2; Bishop, 2003; Norwegian adaptation by Lyster & Horn, 2009). This test was used to measure children's receptive grammar at ages 3;6 and 4;6, respectively. In this test, grammatical comprehension was assessed by using a multiple-choice format, where a picture depicting the target sentence is contrasted with three foils depicting a sentence that is altered by a grammatical or lexical element (Bishop, 2003). There is a block of four items for each grammatical contrast, and the block is passed if the child responds correctly to all four items. Blocks are arranged in order of increasing difficulty, and the test is discontinued after one error or more in five consecutive blocks. The score here is the number of correct responses. Internal reliability for the test is $\alpha = .95$ (Lyster & Horn, 2009).

Clinical Evaluation of Language Fundementals-4 (CELF-4; Semel, Wiig, & Secord, 2003; Norwegian adaptation by Monsrud & Rygvold, 2013). Three subtests were administered to the children at ages 4;6 and 6;0, respectively: *Expressive Vocabulary,* henceforth called 'CELF: Vocabulary', was taken to evaluate the child's ability to name illustrations of people, objects, and actions (i.e., referential naming). Reliability for this scale is $\alpha = .82$ (Monsrud & Rygvold, 2013). Further, the *Word Structure* subtest was used to evaluate the children's knowledge of grammatical rules in a sentence-completion task. Here, the child completes an orally presented sentence that pertains to an illustration, and is required to apply targeted word structure rules such as inflections and derivations. Reliability for this scale is $\alpha = .78$ (Monsrud & Rygvold, 2013). Finally, the *Formulated Sentences* subtest was used to evaluate the ability to formulate compound and complex sentences when given grammatical (semantic and syntactic) constraints. Here, the child was asked to formulate a sentence, using target words or phrases, while using an illustration as a reference. Reliability for this scale is $\alpha = .94$ (Monsrud & Rygvold, 2013). The *Word Structure* and the *Formulated Sentences* scores were combined into a composite score henceforth called 'CELF: Grammar'.

A composite grammar score based on the means of standardised scores from the TROG-2 ($\alpha = .96$) and the two grammar subtests of CELF-4 (Word Structure, $\alpha = .92$ and Formulated sentences, $\alpha = .92$) was computed and used in the correlation analyses at age 4;6. The reliability for this composite score is $\alpha = .69$.

Research design and general procedure

The Tromsø Longitudinal Study of Dyslexia employs a repeated-measures design to monitor how the FR and NoFR group change over the passage of time. That is, children in the two groups undergo the same tests and procedures over a number of occasions. All children were tested at ages 1;6, 2;0, 2;6, 3;0, 3;6, 4;6, and 6;0, ±3 weeks. Thus, they were the same age at all assessment points.

All children were tested individually. Assessments were administered in a laboratory at the university and were videotaped and audio-recorded for later analyses. Each session lasted 2–3 hours and was completed with one examiner and one parent in the room (i.e., up to the age of 4;6). Parents received and completed the CDI form regarding their child's expressive vocabulary and grammar at home a day or two before the visit to the university laboratory. The CDI forms were inspected by the examiners at the clinic to identify possible errors.

Results

Altogether 70% of the participants had a full dataset of all language measures from ages 1;6 to 6;0. For the remainder, the number of missing values in language measures varied from 2 to 8 (3.7–14.8%) due to non-attendance in separate assessments. However, according to Little's MCAR test, missing data was completely at random ($\chi^2(175) = 160.34$, $p > .05$), enabling us to impute the missing values and retain all cases in the study. The multiple imputation option of the SPSS-program was used to impute the missing values. Linear regression was chosen as the method for imputation, and the mean of five imputations was used as a score for each missing value.

All distributions in lexical and grammatical measures approximated normal distribution, except at age 1;6, in which they were right skewed. Logarithmic transformation was applied for the CDI Vocabulary at 1;6, which corrected the right skewness of this measure. In the CDI Grammar at 1;6, 70% of the participants scored 0, and a logarithmic transformation was unable to correct the skewness. As a consequence, it was recoded into three classes (0 = no, 1 = 1–3, 2 = 5–8 signs of grammar skills) to minimize skewness.

Group differences in lexical and grammatical development

Means, standard deviations, and group comparisons with independent sample t-tests in lexical and grammatical measures from ages 1;6 to 6;0 are presented in Table 2. The first research question, the similarity of lexical and grammatical growth in the two groups, was examined with Mixed-Design ANOVAs including age as the within-subjects factor and group (FR, NoFR) as the between-subjects factor. In the first Mixed-Design ANOVA using CDI Vocabulary from ages 1;6 to 3;0, the main effect of age was significant ($F(3,50) = 733.67$, $p < .001$, $\eta_p^2 = .98$), whereas the main effect of group and the interaction effect of time × group were not ($F(1,52) = 0.02$, $p > .05$, $\eta_p^2 = .01$, and $F(3,50) = 1.02$, $p > .05$, $\eta_p^2 = .06$, respectively). Together, these results suggest that the level and growth of vocabulary was similar in the FR and NoFR groups between ages 1;6 and 3;0. In the second Mixed-Design ANOVA, vocabulary growth from ages 4;6 to 6;0 in the two groups was examined using CELF as the vocabulary measure. Again, the main effect of age was significant ($F(1,52) = 144.74$, $p < .001$, $\eta_p^2 = .74$), whereas the main effect of group was not ($F(1,52) = 1.78$, $p > .05$, $\eta_p^2 = .03$). However, between the ages of 4;6 and 6;0, the age × group interaction was also significant ($F(1,52) = 4.64$, $p < .05$, $\eta_p^2 = .08$). Thus, between ages 4;6 and 6;0 the FR and NoFR groups started from a similar level of vocabulary, but the growth of it was steeper in the NoFR group. This steeper growth resulted in a significant group difference in the mean of CELF vocabulary at age 6;0 and a large effect size between the two groups (see Table 2).

In grammar, the similarity of growth in the FR and NoFR groups was examined with three Mixed-Design ANOVAs using CDI from ages 1;6 to 3;0, TROG from ages 3;6 to 4;6, and CELF from ages 4;6 to 6;0 as the grammar measure. In all these analyses the main effect of age was significant ($F(3,50) = 191.04$, $p < .001$, $\eta_p^2 = .92$; $F(1,52) = 108.59$, $p < .001$, $\eta_p^2 = .68$; and $F(1,52) = 150.54$, $p < .001$, $\eta_p^2 = .74$, at ages 1;6–3;0, 3;0–3;6, and 4;6–6;0, respectively), whereas the main effect of group and the interaction effect of time × group were not (age 1;6–3;0: F(1,52) = 0.09, $p > .05$, $\eta_p^2 = .002$ and F(3,50) = 0.92, $p > .05$, $\eta_p^2 = .01$, respectively; age 3;0–3;6: F(1,52) = 0.63, $p > .05$, $\eta_p^2 = .01$ and F(1,52) = 0.21, $p > .05$, $\eta_p^2 = .004$, respectively; and age 4;6–6;0: F(1,52) = 1.65, $p > .05$, $\eta_p^2 = .03$ and F(1,52) = 1.44, $p > .05$, $\eta_p^2 = .03$, respectively). Taken together, the results of Mixed-Design ANOVAs showed that the FR and NoFR groups started their grammar development at the same level and that the growth was also similar in the two groups throughout ages 1;6 to 6;0. However, according to the independent sample t-test, the difference in grammar skills was significant at age 1;6, and the effect size between the FR and NoFR group was moderate in CELF grammar at age 6;0 (see Table 2).

Interdependencies between lexical and grammatical development

Pearson correlations were used, first, to examine both concurrent and cross-lagged associations in lexical and grammatical measures, as well as between two consecutive assessment ages within one domain, i.e., vocabulary and grammar (see Tables 3 and 4 for correlations in the FR and NoFR group, respectively). Although there are some differences in the figures and significances of correlations between the FR and NoFR group, according to the Difference test based on Fisher's z-transformed correlation coefficients (McNemar, 1969), these two groups differed significantly only in four associations: the association was stronger in the FR-group between CDI vocabulary at ages 2;0 and 2;6, on the one hand, and between CDI vocabulary at 2;0 and CDI grammar at 3;0, on the other hand. Moreover, the association was stronger in the NoFR group between CDI grammar at 2;0 and TROG & CELF grammar at 4;6, on the one hand, and TROG grammar at 3;6 and TROG & CELF grammar at 4;6, on the other hand.

Regarding our second research question – interdependencies between lexical and grammatical domains in the FR and NoFR groups – the associations between lexical and grammatical measure are of special interest (please see the upper-right corner in Tables 3 and 4). Moderate to strong correlations, varying from .41 to .89 and .38 to .83 in the FR and NoFR group, respectively, were found between lexical and grammatical measures between ages 1;6 to 3;0. Moreover, moderate or strong associations between lexical and grammatical measures were found also within ages 3;6 to 6;0: correlations varied between .36 and .62, and .49 and .63, in the FR and NoFR group, respectively. Finally, somewhat weaker and partly non-significant associations between the two domains were found when measures from the earlier age range (ages 1;6 to 3;0) were correlated with measures from the later age (3;6 to 6;0) (see Tables 3 and 4).

Significant correlations found between two consecutive time-points from vocabulary to grammar, or vice versa, do not, as such, stand for sufficient evidence of lexical or grammatical bootstrapping. Instead, concurrent and autoregressive associations need to be taken into account to find out the existence of significant cross-lagged associations. Therefore, the relations between lexical and grammatical measures were further modelled using the Mplus 8.0 program (Muthén & Muthén, 1998–2017). Altogether, five different models, instead of one model including all language measures from ages 1;6 to 6;0, were constructed due to small sample sizes in the two groups. Two lexical and two grammatical measures from two consecutive time-points were included into the model at a time (e.g., CDI vocabulary at 1;6 and 2;0 and CDI grammar at 1;6 and 2;0). The time-window of 3;0–3;6 was not inspected, because vocabulary and grammar were measured differently in these two time-points, thus

Table 3. Concurrent and predictive correlations between lexical and grammatical measures in children with family risk of dyslexia (FR group; n = 31)

	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
Lexical measures													
1. CDI, 1;6	0.73***	0.69***	0.53**	0.14	−0.14	−0.14	0.65***	0.68***	0.41*	0.65***	0.16	0.09	0.17
2. CDI, 2;0		0.88***	0.66***	0.30	−0.10	−0.03	0.58***	0.89***	0.54**	0.74***	0.29	0.30	0.39*
3. CDI, 2;6			0.82***	0.50**	0.07	0.15	0.57***	0.77***	0.71***	0.86***	0.41*	0.38*	0.51**
4. CDI, 3;0				0.55**	0.08	0.22	0.46**	0.55**	0.70***	0.83***	0.48**	0.32	0.40*
5. EVT, 3;6					0.39*	0.26	0.20	0.25	0.59***	0.53**	0.53**	0.43*	0.51**
6. CELF, 4;6						0.46**	−0.17	−0.17	0.14	0.07	0.36*	0.62***	0.60***
7. CELF, 6;0							0.14	−0.19	0.11	0.15	−0.12	0.18	0.51**
Grammatical measures													
8. CDI, 1;6								0.53**	0.28	0.56**	−0.08	−0.02	0.16
9. CDI, 2;0									0.54**	0.62***	0.16	0.18	0.26
10. CDI, 2;6										0.76***	0.42*	0.25	0.40*
11. CDI, 3;0											0.42*	0.40*	0.49**
12. TROG, 3;6												0.49**	0.25
13. TROG 4;6 & CELF, 4;6													0.64***
14. CELF, 6;0													

Note. CDI = MacArthur-Bates Communicative Development Inventories (Fenson *et al.*, 1993); EVT = Expressive Vocabulary Test, 2nd edition (Williams, 2007); CELF = Clinical Evaluation of Language Fundamentals, 4th edition (Semel *et al.*, 2003); TROG = Test for Reception of Grammar, 2nd edition (Bishop, 2003). A composite grammar score, based on TROG 4;6 and CELF 4;6, was used at age 4;6; * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 4. Concurrent and predictive correlations between lexical and grammatical measures in children without family risk for dyslexia (NoFR group; n = 23)

	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
Lexical measures													
1. CDI, 1;6	0.64***	0.58**	0.54**	0.09	−0.07	−0.19	0.51*	0.38	0.46*	0.44*	0.25	0.21	0.09
2. CDI, 2;0		0.69***	0.39	0.42*	0.24	−0.23	0.43*	0.81***	0.50*	0.33	0.55**	0.60**	0.42*
3. CDI, 2;6			0.83***	0.52*	−0.06	−0.29	0.44*	0.67***	0.83***	0.76***	0.49*	0.45*	0.42*
4. CDI, 3;0				0.36	−0.05	−0.14	0.43*	0.41	0.73***	0.74***	0.35	0.29	0.35
5. EVT, 3;6					0.48*	0.04	0.33	0.43*	0.52*	0.48*	0.49*	0.50*	0.61**
6. CELF, 4;6						0.43*	0.27	0.15	−0.03	−0.07	0.49*	0.63**	0.63***
7. CELF, 6;0							−0.13	−0.25	−0.19	−0.12	0.09	0.10	0.16
Grammatical measures													
8. CDI, 1;6								0.31	0.34	0.32	0.33	0.23	0.32
9. CDI, 2;0									0.51*	0.26	0.63**	0.69***	0.55**
10. CDI, 2;6										0.84***	0.40	0.35	0.34
11. CDI, 3;0											0.23	0.14	0.24
12. TROG, 3;6												0.80***	0.57**
13. TROG 4;6 & CELF, 4;6													0.76***
14. CELF, 6;0													

Note. CDI = MacArthur-Bates Communicative Development Inventories (Fenson *et al.*, 1993); EVT = Expressive Vocabulary Test, 2nd edition (Williams, 2007); CELF = Clinical Evaluation of Language Fundamentals, 4th edition (Semel *et al.*, 2003); TROG = Test for Reception of Grammar, 2nd edition (Bishop, 2003). A composite grammar score, based on TROG 4;6 and CELF 4;6, was used at age 4;6; * $p < .05$, ** $p < .01$, *** $p < .001$.

possibly violating the assumption of invariance of constructs assumed in panel models (Selig & Little, 2012). Moreover, as 10 cross-lagged associations were inspected altogether, we guarded against type I error by using a strict significance level, .005 (traditional .05 divided by the number of examined cross-lagged paths). We started modelling at each time-window with a saturated model where all possible associations were estimated at the same time, i.e., concurrent, autoregressive, as well as cross-lagged paths. Next, each model was trimmed by removing non-significant cross-lagged paths using the .005 significance level as a criterion. Finally, group × vocabulary and group × grammar interaction variables were added, one by one, to the model to see whether the FR status had any additional effect on the cross-lagged associations. The parameters of all models were estimated using the MLR procedure due to slightly skewed distributions in some of the measures. The goodness of fit of the estimated model was evaluated using five indicators: the χ^2 test, Comparative Fit Index (CFI), Tucker-Lewis Fit Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR).

All significant cross-lagged associations between lexical and grammatical measures with standardized estimates of the loadings are presented in Figure 1. All models fitted the data well (see Figure 1 for the fit-indices presented separately for each model). Results showed, first, that within the early years (1;6 to 3;0) two cross-lagged correlations from vocabulary to grammar were significant: CDI Vocabulary at 1;6 explained 32% of the variance in CDI Grammar at 2;0, and CDI Vocabulary at 2;6 explained 34% of the variance in CDI Grammar at 3;0. Second, one significant cross-lagged correlation from grammar to vocabulary was found, namely CDI Grammar at 2;0 explained 14% of the variance in CDI Vocabulary at 2;6. Third, between ages 3;6 and 6;0, only two significant cross-lagged associations were found, both from grammar to vocabulary: first, age 3;6 grammar explained 11% of the variance in age 4;6 vocabulary, and age 4;6 grammar explained 38% of the variance in age 6;0 vocabulary. All other cross-lagged associations were non-significant. Finally, all group × vocabulary and group × grammar interaction effects on cross-lagged association were non-significant, suggesting that FR status had no additional effect on any of the cross-lagged associations. The only significant effect of group was found at age 6;0, where a negative association between FR status and vocabulary, on the one hand, and grammar, on the other hand, was found, suggesting that having family risk for dyslexia resulted in lower scores in both vocabulary and grammar at age 6;0.

Discussion

Employing a longitudinal multiple-wave design, the first aim of this study was to investigate whether the growth of lexical and grammatical skills was similar in children with and without a familial risk of dyslexia between the ages of 1;6 and 6;0. In line with our expectations, neither lexical nor grammatical development differed significantly between the groups at earlier ages, except for grammar at age 1;6. It appeared that this effect size was large due to the very small variances observed in both groups, as two-thirds of the children scored 0 points in grammar at this very early stage of expressive grammar. On the other hand, the FR group seemed to achieve lower scores when tested at the end of the preschool period (i.e., age 6;0), which yielded moderate to large effects in grammar and vocabulary, respectively. This pattern of results does not align well with those who reported early group-level

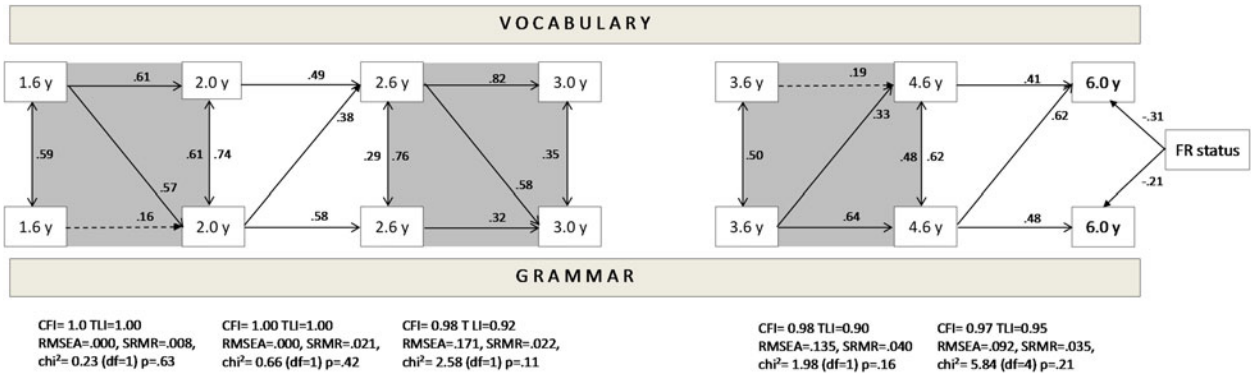

Figure 1. Concurrent, auto-regressive and cross-lagged associations between vocabulary and grammar. All significant paths are presented with solid line and non-significant with dash line together with standardized estimates of the loadings.
Note.
Altogether six different models were constructed: two consecutive ages were included in one model due to small sample size (gray and white rectangles).

differences that diminished at later ages. For example, Chen *et al.* (2017) found a significant difference between total vocabulary scores of the groups only when they were 19–20 months old, and this led the authors to argue for a critical age window, after which the differences might be difficult to discern. In a similar vein, Nash *et al.* (2013) observed that the FR group performed worse on vocabulary and grammar tasks at age 3;6, but that their performance was like that of the NoFR group at age 4;6. The discrepancy between our results and these FR study results might be in part due to the small sample size of our NoFR group, which limited the statistical power needed to detect subtle between-group differences at earlier ages. However, it is important to highlight that group sizes were similar throughout the observation period. Thus, the small sample size cannot fully account for why group-level differences reached significance later rather than earlier in development.

One factor that could explain the inconsistent results of lexical and grammatical skills in FR children may have to do with the extent to which different samples with FR contain children who also show symptoms of developmental language disorder (e.g., difficulties in acquiring words and sentences), due to the well-documented overlap between dyslexia and DLD (Bishop & Snowling, 2004; Snowling & Hulme, 2012; Snowling & Melby-Lervåg, 2016). Given that the degree of this comorbidity reported in the literature varies between samples (e.g., Catts *et al.*, 2005; Nash *et al.*, 2013), it might be argued that vocabulary and grammar deficits could manifest earlier in FR samples which include a relatively higher percentage of children with non-phonological language difficulties. Likewise, the varying number of FR children who later turn out to be dyslexic in different samples may also be responsible for the contradictory results. Problems in broader language skills have mostly been observed in FR children who later developed dyslexia (Snowling & Melby-Lervåg, 2016; van Viersen *et al.*, 2018), suggesting that FR samples that comprise a higher number of FR children with dyslexia might be expected to yield significant group-level differences at early ages. It is also worth mentioning that divergent findings could be attributed to various methodological issues (e.g., data obtained from independent samples vs. same sample of children, utilizing parental reports vs. standardised tests), as well as to different background characteristics of the participating children, such as their native languages. However, as stated earlier, Norwegian is a Germanic language with a similar morphological and syntactical structure to that of English. Therefore, we do not assume that the native language of the current sample would lead to significantly deviant results from the previously reported ones.

The developmental trend observed here might also be related to the magnitude of genetic and environmental influences on language skills, which was shown to change with development (Hayiou-Thomas, Dale, & Plomin, 2012). There is evidence that the genetic influences become increasingly important for variation in language abilities as children get older, whereas the shared environmental effects, which were substantial on early language, become weaker over time (e.g., Hayiou-Thomas *et al.*, 2012; Stromswold, 2001). The fact that all of the participating children, except one who started at a later age, were attending a daycare centre from they were around age 1;0 could have had an equalizing effect on the variation of children's early language skills. Our results might thus suggest that the effect of this shared environment became less influential with age, while the genetic effect of FR increased, resulting in significant difference between the groups towards the end of early childhood.

In fact, in Lyytinen and Lyytinen's (2004) study, results generally supporting this line of thinking were found. Although the group-level differences reached significance earlier compared to the current findings, possibly due to the reasons discussed above, FR and NoFR children performed similarly at earlier assessment points (i.e., ages 2;0 and 2;6). However, at age 3;6, FR children had significantly lower scores on lexicon and grammar than their NoFR peers, and between-group differences were significant at age 5;0 as well. The authors suggested a developmental trend according to which delays and deficits in the lexical and grammatical skills of FR children might become more evident with increasing age. A possible reason postulated for this result is that subtle difficulties in speech perception are often present in FR children, and the cumulative effects of these difficulties may be observed in some areas of linguistic development, including vocabulary and expressive language (Lyytinen & Lyytinen, 2004). Indeed, recent research has revealed that speech perception deficit could implicate a deficient development of phonological representations and was related to later poor language skills in FR children (Lohvansuu *et al.*, 2018; Snowling *et al.*, 2019). Therefore, a rather comprehensive account, which suggests that poor phonological skills cause a bottleneck in language processing that can lead to adverse cascading effects on the development of vocabulary and grammar (Catts & Adlof, 2011), may also have the potential to explain why FR children, as a group, seem to develop relatively lower skills in vocabulary and grammar over time.

The current results also suggest some parallels with recent evidence, which indicated a significant association between being at family risk of dyslexia and late-emerging language difficulties (Snowling *et al.*, 2016; Zambrana *et al.*, 2014). These studies reported that, although showing comparable early language skills to those of their NoFR peers, a number of FR children seemed to develop language difficulties later in childhood. Snowling *et al.* (2016) argue that these results might be suggestive of a different aetiology, possibly of genetic origin, which leads to atypical language trajectories in some FR children. Therefore, it might be that some of the children in the FR group had late-onset delay, particularly in vocabulary between ages 4;6 and 6;0, which resulted in a significant difference with a large effect size between the FR and NoFR groups at age 6;0. Despite failing to reach significance, the effect size between the groups was moderate in grammar at this age, suggesting that some of these FR children might also show late-onset delay in grammar, though to a lower degree than in the vocabulary domain. The children in this study have not been tested for language impairment yet. However, it is noteworthy that the parents of FR children had significantly lower scores on verbal comprehension (WASI; Ørbeck & Sundet, 2007) than did NoFR parents, and this may suggest that several of these FR children might be at risk for language impairment. Furthermore, a large body of evidence suggest that problems in oral language development are among the significant risk factors underpinning later reading difficulties (Hulme *et al.*, 2015). Thus, our findings point to the importance of having a continued focus on the language development of FR children in the years preceding school entry for enhancing the possibility of early detection of those who are at high risk of reading problems.

Concurrent and cross-lagged associations between vocabulary and grammar

The second aim of this study was to examine the pattern of developmental interdependencies between these skills and to explore whether FR status exerts an effect on the associations between vocabulary and grammar. Our analyses regarding the concurrent correlations between lexical and grammatical measures revealed, as expected, significant associations. These contemporaneous relations, which were consistently strong over the course of the preschool period, suggest that lexicon and grammar appear to develop in tandem in both FR and NoFR children. They extend previous findings, which found a tight link between these constructs, particularly in the early years of language development (i.e., up to approximately age 3;0; e.g., Bates & Goodman, 2001; Braginsky *et al.*, 2015; Thordardottir *et al.*, 2002), by showing a close relationship between them also from ages 4;6 to 6;0.

As regards the question of directional effects between vocabulary and grammar development across time, our results provided evidence for both lexical and syntactic bootstrapping between ages 1;6 and 6;0. Despite detecting a significant negative relation between FR status and vocabulary and grammar scores at the last assessment point (i.e., 6;0), we found no effect of group status on the cross-lagged associations. This finding suggests that children in this study had a similar pattern of development with respect to the temporal direction of the relationship between vocabulary and grammar, regardless of whether they had a family history of dyslexia or not. Previous research suggests that difficulties in vocabulary and grammar might be more related to dyslexia status rather than to FR status (Snowling & Melby-Lervåg, 2016; van Viersen *et al.*, 2018), and this may explain the non-significant differences in cross-lagged associations between the two groups to some extent. However, since the present study is the first to examine this issue, our results need to be replicated in future studies.

During the period from ages 1;6 to 3;0, evidence of a significant association of early vocabulary knowledge with subsequent grammar emerged between ages 1;6 and 2;0, and also between 2;6 and 3;0. These findings provide support for lexical bootstrapping, suggesting that children who make more gains in expressive vocabulary tend to also make large gains in grammar during the following time period. Our observation that lexical skills at 1;6 predicted grammatical growth at 2;0, rather than the reverse, seems to be consistent with the critical mass hypothesis (Marchmann & Bates, 1994), according to which growth in syntactic and morphological structures in the early stages of language development depends on the extent of expressive vocabulary. Since the earlier studies with a similar design to ours did not include children who were younger than age 2;0, the current results extend the cross-lagged findings of past research to a younger age. In addition, analyses revealed syntactic bootstrapping between ages 2;0 and 2;6, suggesting that children's prior grammatical skills contribute to the subsequent development of their lexical skills. This result might be due to the fact that most children typically produce their multiword utterances by 24 months, and this development can influence subsequent lexical acquisition significantly.

Before going any further, an important point regarding the observed temporal ordering in the acquisition of lexicon and grammar should be mentioned. It has been argued that this pattern of data could simply arise from the measurement properties of the CDI inventory, which is widely used to assess early language development (Hoff *et al.*, 2018). That is to say, an observed ordering relation between two variables might indeed be an artefact of a non-linear mapping between a construct and its measure rather than a true reflection of the relationship between those variables (Dixon & Marchman, 2007). However, compelling evidence from multivariate genetic analyses suggests substantial genetic correlation between the CDI vocabulary and grammar scales (Dale *et al.*, 2000) justifying the use of the CDI to assess language development in toddlerhood. Furthermore, being compatible with bootstrapping mechanisms, statistical learning accounts also provide some support for the observation that lexical growth drives grammatical development in the earliest stages of language acquisition. According to statistical language learning, children are sensitive to the probability with which syllables co-occur in their phonological input, and by making use of this information they are able move from surface structure to deeper structure, such as tracking syllables to find words and then an underlying grammar to learn about phrasal units (Romberg & Saffran, 2010; Thiessen, 2017).

From age 3;6 to school entry age, children displayed two significant cross-lagged correlations, both consistent with syntactic bootstrapping. In line with our expectations, we found evidence that level of children's grammar predicted subsequent growth in their vocabulary from ages 3;6 to 4;6, and from ages 4;6 to 6;0, suggesting a greater influence of grammatical skills on the development of vocabulary knowledge than vice versa during this period. These results might be a reflection of the fact most children display a burst in their grammatical development during the third and fourth years of life, adding passives, relative clauses, and other complex forms (Bates & Goodman, 2001). Moreover, our finding of lexical bootstrapping and syntactic bootstrapping occurring between ages 1;6 and 6;0 provides some partial support for the notion of bi-directional bootstrapping, which suggests that the two constructs contribute to development of one another across time. Unlike some previous research (Dionne *et al.*, 2003; Moyle *et al.*, 2007), which demonstrated bi-directional bootstrapping due to lexical and syntactic bootstrapping co-occurring in the same time period, the current bootstrapping processes occurred in a sequential fashion rather than simultaneously over time. However, different time intervals between measurement occasions that were used to explore bootstrapping effects in these two studies as well as in the Hoff *et al.* (2018) study, do not overlap well with ours, which in turn make the results relatively less comparable. That said, in agreement with a framework of development discussed by Hirsh-Pasek, Tucker, and Golinkoff (1996), we suggest that considering the potential contribution of lexical growth to grammatical growth and vice versa "as systems of developing knowledge that are mutually informing and always available, but with differing weights along the developmental trajectory" (p. 464) might also help to explain why bootstrapping was detected only at certain ages and in differing directions in young children.

Although strengthened by the longitudinal nature of the study, and the statistical modelling taking this into account, some limitations of the present data should be pointed out. First, the relatively small sample size of the groups may have limited the ability to detect small directional influences between vocabulary and grammar domains, as well as differences between the groups. Therefore, further research with a larger sample is needed for broader generalisations. Second, it is important to emphasise that, although they provide valuable insights into the possible temporal effects of the variables over time, cross-lagged panel analyses remain correlational. As such, we cannot rule out the possibility of third-variable explanations for the observed effects (Morgan & Winship, 2014), and draw causal inferences from the current findings. Therefore, intervention research designed to establish the directionality of the causal interaction between vocabulary and grammar would be a valuable future direction.

Third, we applied single, relatively coarse-grained tests to assess lexical and grammatical knowledge (except for utilizing two grammar tests at age 4;6), which means that our results are necessarily limited by these particular measures. Had resources allowed, multiple measures for each construct at all time-points would have been preferable. However, it should be noted that the measures selected for this study were reported to have good internal consistency and test–retest reliability.

Fourth, FR and NoFR parents differed in terms of their educational level. However, family income did not appear to be affected by this difference. Several studies have pointed towards a relation between children's language ability across domains and the socioeconomic status (SES) of their families (see Pace, Lou, Hirsh-Pasek, & Golinkoff, 2017, for a review). Because the children in the current study come from families with similar SES backgrounds, and the level of education in both groups was generally high, we do not assume that this educational level difference would lead to differences between the FR and NoFR children's language outcomes. Future studies might consider involving a more representative sample of families with low SES, as this could reveal different results from ours.

Overall, given the findings that the FR group performed more poorly than the NoFR group, particularly on vocabulary but also, though to a lesser degree, on grammar at school entry age, it may be argued that some of the FR children are more at risk of developing reading impairment and thus more in need of early intervention. Relatedly, it may also prove useful to monitor the language development of children with a family history of dyslexia, even though they seem to be showing typical early oral language skills. Moreover, current results did not reveal an effect of FR status on the temporal relationship between lexicon and grammar across time, suggesting that it might be the dyslexia outcome rather than the FR status which has a significant effect on the bootstrapping mechanisms in at-risk children. Due to the longitudinal nature of the study, in future work we will be able to investigate this hypothesis.

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Study II

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School-entry language outcomes in late talkers with and without a family risk of dyslexia

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Keywords: family-risk of dyslexia, late talkers, emerging developmental language disorder, vocabulary, grammar

Abstract

Children with familial-risk of dyslexia (FR) and children with early language delay are known to be at-risk for later language and literacy difficulties. However, research addressing long-term outcomes in children with both risk-factors is scarce. This study tracked FR and No-FR children identified as late-talkers (LTs) at age 2 years and reports development from 4;6 through 6 years. We examined the possible effects of FR and LT-status, respectively, on language skills at school-entry, and whether FR-status moderated the associations between 4;6-year and 6-year language scores. Results indicated an effect of LT-status on language at both ages, while FR-status affected language skills at age 6 years only. The interaction between LT and FR-statuses was not significant, implying that LT-status affected language skills independent of the child's FR-status. A proportion of LTs developed typical language at 6 years, while some FR-children with typical vocabulary skills in toddlerhood had emerging developmental language disorder by school-entry. FR-status had a moderating effect on the association between expressive grammar at ages 4;6 and 6 years. Possible explanations for FR's effect on language skills are discussed. We highlight limitations in the study-size and suggest how these preliminary findings can inform future research.

Keywords: family risk of dyslexia, late talkers, emerging developmental language disorder, vocabulary, grammar

School-entry language outcomes in late talkers with and without a family risk of dyslexia

Dyslexia is a heritable language-based disorder characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities, which are often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction (Lyon, Shaywitz, & Shaywitz, 2003; Olson, 2011; Vellutino, Fletcher, Snowling, & Scanlon, 2004). Poor phonological processing is assumed to be the major cognitive risk factor for literacy impairments in dyslexia (Snowling, 2019). The aetiology of dyslexia is multifactorial, involving a complex interaction of genetic factors with environmental influences (Snowling & Melby-Lervåg, 2016; van Bergen, van der Leij, & de Jong, 2014). A recent meta-analysis of studies of children at familial risk (FR) of dyslexia has reported that approximately 29-66% of these children develop a reading disorder later in life, confirming that family history is one of the earliest risk indicators of dyslexia (Snowling & Melby-Lervåg, 2016). This meta-analysis has further revealed different developmental trajectories in language development in FR children compared to those with no familial risk (NoFR). FR children typically have problems in the phonological domain; however, they tend, as a group, to perform more poorly than their NoFR peers on tasks assessing lexical and grammatical knowledge in the preschool years (XXX, 20XX; Carroll & Myers, 2010; Gallagher, Frith, & Snowling, 2000; van Viersen et al., 2018). This can be taken to suggest that some of these children might also be at risk for developmental language disorder (DLD; Bishop et al., 2017; Bishop & Snowling, 2004)

It is important to highlight here that different diagnostic terms, such as language impairment and specific language impairment, have been used to refer to children whose language difficulties are not due to physical, cognitive or neurological conditions (Conti-Ramsden, Durkin, Toseeb, Botting, & Pickles, 2018). In line with the current recommendation for the use of DLD as the established term for these children (Bishop et al., 2017), this paper utilizes the terminology of DLD, both in reference to our subsample (considered to be 'at risk of DLD') and in reference to previous literature. This is also in line with recent longitudinal studies, which have adopted this terminology (e.g., St Clair, Forrest, Yew, & Gibson, 2019). DLD typically manifests itself as a difficulty in acquiring vocabulary and grammar skills (Leonard, 2014). Research on the trajectory of DLD has shown that although it was originally thought to be a childhood disorder, DLD can be persistent after school entry and lead to poorer literacy and academic achievement (Conti-Ramsden et al., 2018; Snowling, Adams, Bishop, & Stothard, 2001).

A recent study by Snowling, Nash et al. (2019) followed children at FR of dyslexia, children with language difficulties, and children with typical development (N = 234) from age 3;6 years and classified them as having dyslexia or DLD at 8 years. The authors reported that language difficulties, including vocabulary and grammar, were small in early childhood. However, they appeared to increase with age and were large after school entry in both the dyslexia-only, the DLD-only, and the dyslexia+DLD group. Along these lines, longitudinal data from different studies have pointed out that oral language difficulties are most evident in FR children who go on to become dyslexic (e.g., Carroll, Mundy, & Cunningham, 2014; Snowling, Muter, & Carroll, 2007; Torppa, Lyytinen, Erskine, Eklund, & Lyytinen, 2010; van Viersen et al., 2018), suggesting that early signs of dyslexia include difficulties not only in phonological but also in broader language skills.

It is widely assumed that late emergence of oral language (i.e., late talking) in toddlerhood is the first marker of difficulties in language development (Zubrick, Taylor, Rice, & Slegers, 2007). The limited evidence suggests that FR children with late language emergence are less likely to overcome their difficulties than their late talking peers without FR and that these children frequently display deficits in reading and spelling (Lyytinen, Eklund, & Lyytinen, 2005). Additional research is, therefore, needed to gain more insight into the longitudinal development of oral skills in FR children who had been identified as late talkers.

Language development in late talking children

Children typically acquire their first spoken words at around 12 months and begin to put words together by 24 months (Zubrick et al., 2007). However, late talking children approach these language milestones much later in the absence of a known underlying pathology, such as a neurological, sensory, or cognitive deficit (Desmarais, Sylvestre, Meyer, Bairati, & Rouleau, 2008). These children aged between 18-35 months are often referred to as late talkers (LTs; Rescorla, 1989, 2011). Some LTs present with an expressive delay only, whereas others have delayed receptive language as well (Rescorla, 2013). The most common measure used to identify LTs is limited productive vocabulary based on a parental report (Desmarais et al., 2008; Rescorla & Dale, 2013a), whereas the criteria for late talking vary widely across studies with cut-off scores ranging from approximately the 2nd to the 30th percentile (Fisher, 2017; Jones, 2003).

A number of varying long-term linguistic outcomes have been noted in LTs (e.g., Rescorla, 2011; Rescorla & Dale, 2013a, for overviews), which is not surprising when the heterogeneity in ages at intake, expressive vocabulary sizes, and comprehension abilities is taken into account. In general, evidence suggests a good prognosis for LTs as approximately 50-75% develop appropriate language skills in subsequent years (Paul & Ellis Weismer, 2013). These children typically perform within age expectations on receptive and expressive vocabulary as well as receptive grammar by 3 to 5 years of age (Ellis & Thal, 2008; Moyle, Stokes, & Klee, 2011; Paul, Murray, Clancy, & Andrews, 1997; Rescorla, 2011). On the other hand, they seem to have ongoing delay in expressive grammar development throughout the preschool period (Ellis Weismer, 2007; Rescorla, Dahlsgaard, & Roberts, 2000; Rescorla & Turner, 2015; Rice, Taylor, & Zubrick, 2008), suggesting that this particular area of language might be relatively more challenging to master for LTs at the group level.

Evidence also shows that in a subset of late talking children (around 20%) language difficulties persist throughout the school years (Rice et al., 2008; Rescorla & Dale, 2013a), leading to a diagnosis of DLD that is often associated with literacy impairments, poor social competence, attention deficit, and behavioural problems (Henrichs et al., 2011). A number of longitudinal large-scale studies sought to explore the contribution of demographic, genetic, linguistic and environmental factors to longer-term language outcomes in late talking children (e.g., Henrichs et al., 2011; Ghassabian et al., 2014; Lyytinen, Poikkeus, Laakso, Eklund, & Lyytinen, 2001; Reilly et al., 2010). For example, Lyytinen et al. (2001) traced language skills from 14 months to 3;6 years in Finnish FR children (N = 106) and NoFR children (N=94) and they identified two late talking groups, one with FR (N = 20) and one without (N = 14). For the full sample (N = 200), children' early play and receptive and expressive language skills, parents' education, and FR status explained 34% and 48% of the variance in receptive and expressive language, respectively, at age 3;6 years. Interestingly, Lyytinen et al. (2001) found that FR status did not contribute children's receptive language, whereas it made a significant contribution to expressive language.

Henrichs et al. (2011) assessed predictors of 30 months vocabulary skills in a sample of 3,759 Dutch children. Their regression model, which included multiple perinatal, demographic, and maternal factors together with earlier language scores, explained 18% of the variance in expressive vocabulary at 30 months, leaving most variance unexplained. Expressive vocabulary at 18 months appeared to account for 11% of this variance. Following-up 2,724 of the children from Henrichs et al.'s sample, Ghassabian et al. (2014) examined the relationship between late talking and vocabulary comprehension at school age. They reported that their prediction model explained 15% of the variance in receptive vocabulary at age 6 years. Receptive and expressive vocabulary at 18 months accounted for 0.3% and 1.5% of the total variance, respectively, and expressive vocabulary at 2;6 years explained only 2%. These findings suggested that the model's ability to predict long-term language outcomes was limited. Ghassabian et al. also found that most LTs had normal range vocabulary comprehension score at age 6 years and that the majority of children with receptive vocabulary difficulties at 6 years had no expressive vocabulary delay at 18 months and 2;6 years.

The latter finding reported by Ghassabian et al. (2014) suggests an emerging DLD profile, which has been observed in 6-19% of children in several longitudinal studies (Armstrong et al., 2017; Poll & Miller, 2013; Reilly et al., 2010; Rice et al., 2008). Despite having language skills in the normal range early in development, children with this profile eventually meet criteria for DLD at a later time point (Moyle et al., 2011). Interestingly, two recent studies found a significant association between FR of dyslexia and emerging DLD (Snowling, Duff, Nash, & Hulme, 2016; Zambrana, Pons, Eadie, & Ystrom, 2014). Following the development of Norwegian children (N = 10,587) from age 3 to 5 years, Zambrana et al. (2014) found that FR for literacy difficulties was the most crucial risk factor for emerging DLD, and children born with FR had significantly higher odds for persistent language difficulties. Likewise, Snowling et al. (2016) followed English-speaking children (N = ~220), who were initially classified as having either FR of dyslexia or risk of DLD or typical language, from age 3;9 to 8;1 years. In this study, in addition to the two groups of children, one with resolving and one with persisting

DLD, a third group was identified. Children in this third group appeared to have emerging DLD at age 8;1 years, despite having average oral language abilities in early childhood. Importantly, FR children were overrepresented in this group, stressing the importance of following language skills of FR children from early years through to school age to track possible emerging difficulties in their linguistic growth.

The link between early language delay and difficulties with literacy acquisition

The underlying cause of vocabulary delay in LTs is unknown. However, a phonological basis has been suggested due to observed delays in babbling frequency and complexity in infants and toddlers who later were identified as LT (MacRoy-Higgins, Shafer, Fahey, & Kaden, 2016). In support of this, Ellis Weismer, Venker, Evans, and Moyle (2013) found that LTs are less sensitive to phonological properties of novel words during word learning tasks than typical children. In a similar vein, several studies have found that FR is associated with a deficit in perception and segmentation of speech, which may eventually lead to phonological deficits (Lohvansuu, Hämäläinen, Ervast, Lyytinen, & Leppänen, 2018; Snowling, Lervåg, Nash, & Hulme, 2019). Taken together, these findings point out that early delays and deficiencies in phonological processing skills are observed, though to varying degrees, in late talking children as well as in FR children of dyslexia.

Converging evidence shows that phonological awareness is one of the most crucial predictors of variation in learning to decode print in alphabetical languages and that preschool children with deficient phonological skills run a greater risk of developing problems with word decoding (Caravolas et al., 2012; Kahmi & Catts, 2012). However, the end goal of reading is comprehension, which requires access to the meanings of words and higher level processes such as sentence integration and inferencing (Snowling & Hulme, 2012). Consequently, literacy development does not only depend on the phonological skills but also on the broader oral language skills, including vocabulary and grammar, that children bring to the task of reading. For instance, in a study of English FR children (N = 245), Hulme, Nash, Gooch, Lervåg, and Snowling (2015) demonstrated that language skills at age 3;6 years predicted the preliteracy skills (i.e., phoneme awareness, rapid naming, and letter-sound knowledge) at age 4;6 years, which in turn predicted word-level literacy at 5;6 years. Furthermore, Hulme et al. (2015) found that oral language skills assessed at the age of 3;6 years had a direct influence on reading comprehension at 8;6 years, indicating that development of decoding as well as reading comprehension abilities depend on oral language skills. This study also showed that children with family history of dyslexia had broad deficits in oral language skills in the preschool years. Importantly, a proportion of these children met the criteria for the diagnosis of DLD, highlighting the overlap between risk factors for language and literacy disorders in FR samples (Bishop & Snowling, 2004; Nash, Hulme, Gooch, & Snowling, 2013).

A point to note regarding Hulme et al.’s (2015) study is that children with FR of dyslexia and children with a risk of DLD were combined into one single group in the data analyses. This makes it difficult to rule out whether the observed effect of FR on later language skills and reading development was due to children’s FR status or due to the potential influence of language difficulties of those who were at risk of DLD. Importantly, results from prospective studies conducted in languages with more transparent orthographies than English (e.g., Dutch: van Viersen et al., 2017, 2018; Finnish: Torppa et al., 2010) suggest that the influence of FR on language and reading development is not related to children’s FR status, but rather to their reading status (i.e., dyslexic or not). For example, in van Viersen et al.’s (2017) study, although FR dyslexic children had poorer vocabulary scores than FR non-dyslexic and control children between ages 17 and 35 months, the latter two groups did not differ from each other. This finding suggests that poor early vocabulary is associated with dyslexia status not with FR. Thus, in studies comparing FR vs. NoFR children only, it remains unclear to what extent an overall significant effect of FR on language skills reflects children's FR status, reading status or DLD-risk status.

Results from several studies have suggested an association between late talking and lower outcomes in reading and spelling throughout the school years (e.g., Lyytinen, Eklund, & Lyytinen, 2005; Psyridou, Eklund, Poikkeus, & Torppa, 2018; Rescorla, 2002, 2005, 2009). In her longitudinal study, Rescorla (2002) examined language and reading outcomes in LTs and controls (N = 59) at 6 to 9 years of age and reported that the two groups did not differ in reading skills at ages 6 and 7 years, when all children were in the early stages of learning to read. However, significant group differences were found in aggregate measures of reading (i.e., decoding, comprehension, spelling, and written language) at 8 and 9 years, suggesting that LTs, as a group, may show lower performance in a wide range of reading skills that can be more apparent as literacy demands increase over time. Similar results were reported by Lyytinen et al. (2005), who followed a sample of Finnish children with and without FR (N = 107, N = 93, respectively) from 2 years until the end of the second grade (*M* = 8;9 years). A subsample of late talkers (N = 22 FRLT, N = 10 NoFRLT) was also identified. The authors found that in comparison with LTs in the NoFR group, late talking FR children were more likely to experience persistent difficulties in both receptive and expressive language at ages 3;6 and 5;6 years. Further, the combination of FR of dyslexia and late talking was reported to impede the development of reading, reading comprehension, and spelling skills in the early grades. A follow-up investigation of reading development in the same sample between ages 8 and 16 years has reported that late talking predicts reading comprehension, but not reading fluency and that a deficit in both receptive and expressive vocabulary together with FR of dyslexia is a stronger risk marker for difficulties in reading comprehension (Psyridou et al., 2018).

The present study

Family risk of dyslexia and early expressive language delay are known to place children at increased risk for later language and literacy problems (Rescorla & Dale, 2013a; Snowling & Melby-Lervåg, 2016, for overviews). However, research addressing the language development and long-term outcomes in children with both risk factors is still scarce. Most FR studies of dyslexia do not report original expressive vocabulary data (i.e., an index measure of late talking) at age 2 years and, consequently, do not have a clearly defined LT group. An exception was the study by Lyytinen et al. (2005), which implied that FR status might moderate the language outcomes, although such an effect was not directly examined by the authors. In the present study, we were able to test whether FR status moderated the association between 4;6 years and 6 years language skills in children. In addition, we examined the possible interaction effects between FR and LT statuses, which were not reported in Lyytinen et al. (2005). A study by Carroll and Myers (2010), which explored the interaction between FR of dyslexia and language status in children, is comparable to ours to some extent. Carroll and Myers reported measures from oral language tasks in a group of English children with FR (N = 46), children receiving speech and language therapy (N = 36), and typically developing children (N = 128) aged 4 to 6 years. Their results indicated a significant effect of speech and language-therapy group status on both vocabulary and grammar scores, whereas FR status did not have such an effect. There were also no significant interactions between speech and language-therapy and FR statuses, suggesting that children in the speech and language-therapy group did not manifest different strengths and weaknesses on these tasks depending on their FR status.

In this small-scale study, we investigated whether FR of dyslexia and late talking affect subsequent language abilities. To do so, we examined lexical and grammatical skills in a group of FR and NoFR children who were initially assessed at 2 years and were followed up at ages 4;6 and 6 years. We posed the following research questions:

(a) What is the effect of FR and LT status on vocabulary and grammar outcomes at ages 4;6 and 6 years, respectively? Furthermore, what is the proportion of children, if any, who were at risk of DLD, at the age 6 follow-up? Based on the findings that FR children's difficulties in vocabulary and grammar seem to increase over time (Snowling, Nash et al., 2019), we hypothesized that FR status might have a main effect on oral language outcomes at 6 years rather than at 4;6 years. Late talking children generally develop age appropriate skills in expressive vocabulary and receptive grammar by 3 to 5 years of age (Moyle et al., 2011; Paul et al., 1997), whereas their difficulties in expressive grammar tend to be more protracted (Rescorla & Turner, 2015; Rice et al., 2008). We thus anticipated that we would not detect a significant effect of LT status on expressive vocabulary and receptive grammar at ages 4;6 and 6 years, but instead find an effect on expressive grammar skills at both ages. We further expected that some of the LTs (with or without FR) would have recovered from their early delays and develop typical language skills by age 6 years, whereas others would have persistent language problems (Rescorla, 2011). As some evidence suggests FR status as a potential risk factor for emerging DLD, it was also hypothesized that a number of FR children with typical expressive vocabulary in toddlerhood might have emerging DLD at 6 years (Snowling et al., 2016; Zambrana et al., 2014). It should be highlighted that due to the small sample size of the subgroups, this research question was of exploratory nature and examined using descriptive data only.

(b) How much of the variability in expressive vocabulary, and in receptive and expressive grammar at age 6 years is explained by children's group statuses (LT and FR) and earlier language skills assessed at the age of 4;6 years? Does FR status moderate the associations between 4;6 years and 6 years language skills? Reported findings suggest that early language skills, together with children's group status, account for higher variance in expressive than in receptive skills (Lyytinen et al. 2001). We therefore anticipated that language skills age 4;6 years together with group statuses would explain more variance in expressive than in receptive language outcomes at 6 years. To our knowledge, no previous research has examined whether FR status moderates the effect of earlier language skills on later language development. The study by Lyytinen et al. (2005) suggests that this might be the case, although the issue of moderation was not directly addressed. We thus hypothesized that FR status might moderate the 4;6-year language skills in predicting the 6-year language outcomes.

Method

Participants

The 46 children reported here participated in the prospective XXX Longitudinal Study of Dyslexia. All children were monolingual Norwegian and they had no known neurological conditions. There was no difference in general cognitive ability between the FR group (*M* = 105.16, *SD* = 8.90) and the NoFR group (*M* = 108.64, *SD* = 9.28) t (51) = 1.14, p = .175 at age 24 months (Bayley, 2006).

The families were recruited from the Arctic region of Norway via advertisements in local newspapers and brochures at local child health clinics. The families were selected in a three-stage procedure. In stage 1, parents who volunteered to participate in the study completed a short questionnaire. The questionnaire asked whether the parent had ever experienced reading and spelling problems and whether close relatives (i.e., their own parents and siblings) had experienced such problems (on a yes/no scale). In stage 2, parents were invited to a semi-structured interview. A detailed questionnaire was mailed to the parents before the interview. Parents who reported current impairments and/or a history of reading and writing impairments were asked to give a more detailed description in the interview. In stage 3, all parents were tested on a wide battery of literacy tests to validate their self-reported reading and spelling abilities. Parents were also tested on a wide battery of reading-related cognitive skills (see XXX, 20XX, for a more detailed description of the tests and procedures employed).

Altogether 53 children started as participants in the XXX, but unfortunately seven of the families dropped out from the project during the follow-up period due to relocation outside the region. Little’s Missing Completely at Random test showed that missing data were not completely at random χ^2 (df = 6) = 19.52, p < .01. Further comparisons revealed that those who withdrew from the study had poorer productive language skills measured with the MacArthur-Bates Communicative Development Inventories at age 2 years (t(14.54) = -3.62, p < .01) compared to children who stayed in the longitudinal follow-up (up to age 6 years). Data for the seven children who dropped out from the study were not used in the current analyses.

Family risk (FR) group

If one of the parents (or both) performed below –1 standard deviation on a composite score of standardized measures of reading fluency and spelling, and, if this parent (or both) had self-reported history of reading problems, the child was classified as being at FR (see also XXX, 20XX, for more details). According to these criteria, 24 children (10 girls, 14 boys) were categorised as being at FR of dyslexia.

No family risk (NoFR) group

Children whose parents performed within normal range on standardised literacy tests, and had no self-reported history of reading impairments, formed our no-FR group. According to these criteria, 22 children (10 girls, 12 boys) were allocated to the NoFR group.

Family characteristics

Table 1 displays demographic variables and characteristics for FR and NoFR parents at the beginning of the study. Parents' educational level is indexed by 1 = compulsory school (year 1-10); 2 = upper secondary school/high school (year 11-13); 3 = bachelor's degree; 4 = master's degree and/or PhD, respectively. Education after compulsory school is indexed by the number of years completed after Year 10 in lower secondary. Household's total income in Norwegian Krone (NOK) is indexed by 1 = less than NOK 600,000; 2 = between NOK 600,000 and 700,000; 3= between NOK 700,000 and 900,000; and 4= NOK 900,000 or more. Performance IQ was assessed by Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999; Ørbeck & Sundet, 2007) and the scaled scores were reported.

There were no group differences on any demographic variables except educational level, that is, NoFR-parents had significantly higher educational level compared to FR-parents. The household income was however unaffected by differences in extent of education. There were no group differences in general ability (as indexed by Performance IQ) or reading comprehension. However, there were large group differences on tests measuring decoding and spelling skills (XXX, 20XX).

Instruments

Defining expressive vocabulary delay at 2 years

The MacArthur-Bates Communicative Development Inventories: Words and sentences (CDI W&S; Fenson et al., 1993, 2007; Norwegian adaptation by Kristoffersen & Simonsen, 2012) was used to identify late talkers for the study. Parents completed the CDI W&S form, and items marked as "word produced by the child" were summed to yield the CDI productive vocabulary score (maximum score of 731). The reported reliability for the CDI W&S Vocabulary checklist, Cronbach's α is .99 (Kristoffersen & Simonsen, 2012).

Children were classified as LTs if their CDI W&S productive vocabulary scores were in the lower 20th percentile of the gender-specific normative values. This is less stringent than the more commonly used 10th percentile, but was adopted to achieve adequate numbers of LT cases for analysis. More liberal cut points have been reported in the literature, though (e.g., the 30th percentile for LTs aged 25-41 months in Jones, 2003; the 20th percentile for LTs aged 21-24 months in Rujas, Casla, Mariscal, Villaseñor, & Sanz, 2019). There is still little scientific basis for selecting the precise criterion for late talking (Rescorla & Dale, 2013b). Therefore, in keeping with Marchman and Fernald (2013), the term late talker is used descriptively in the present study, referring to those who fall at the low end of the continuum in language production (i.e., the lowest 20th percentile). Using this criterion, six children in the FR group and six children in the NoFR group were determined as LTs.

Receptive grammar measure at 4;6 years

The Test for Reception of Grammar-2 (TROG-2; Bishop, 2003; Norwegian adaptation by Lyster & Horn, 2009) was used to measure children's receptive grammar skills at age 4;6 years. This test, henceforth called 'Receptive Grammar TROG 4;6', assessed grammatical comprehension by using a multiple choice format, where a picture depicting the target sentence is contrasted with three foils depicting a sentence that is altered by a grammatical or lexical element. There is a block of four items for each grammatical contrast, and the block is passed if the child responds correctly to all four items. Blocks are arranged in order of increasing difficulty, and the test is discontinued after one error or more in five consecutive blocks. The score here is the number of correct responses. Internal reliability for the test is α = .95 (Lyster & Horn, 2009).

Expressive vocabulary and expressive grammar measures at 4;6 years

Four subtests from *The Clinical Evaluation of Language Fundementals-4 (CELF-4*; Semel, Wiig, & Secord, 2003; Norwegian adaptation by Monsrud & Rygvold, 2013) were administered to the children to measure their vocabulary and grammar knowledge at age 4;6 years. The CELF-4 is not normed for age 4;6 years in the Norwegian version (normed for age 5 years and over), and therefore, the scores were standardized based on the means and standard deviations of the current sample before calculating arithmetic means used in the analyses. No floor effects were detected.

The *Expressive Vocabulary* subtest, henceforth called ‘Expressive Vocabulary CELF 4;6’, was taken to evaluate the children’s ability to name illustrations of people, objects, and actions (i.e., referential naming). Reliability for this subtest is α= .82 (Monsrud & Rygvold, 2013).

Scores from three subtests of CELF-4 (*Word Structure*, *Formulated Sentences*, and *Recalling Sentences*) were standardized and then combined into a composite score henceforth called ‘Expressive Grammar CELF 4;6’. Cronbach Alpha reliability for this composite score is .68. The *Word Structure* subtest was used to evaluate the children’s knowledge of grammatical rules in a sentence–completion task. Here, the child completes an orally presented sentence that pertains to an illustration, and is required to apply targeted word structure rules such as inflections and derivations. Reliability for this subtest is α= .78 (Monsrud & Rygvold, 2013). The *Formulated Sentences* subtest was used to evaluate the ability to formulate compound and complex sentences when given grammatical (semantic and syntactic) constraints. Here, the child was asked to formulate a sentence, using target words or phrases, while using an illustration as a reference. Reliability for this subtest is α= .94 (Monsrud & Rygvold, 2013). The *Recalling Sentences* subtest was used to evaluate the ability to recall and reproduce sentences of varying length and syntactic complexity. Here, the child imitates sentences presented orally by the examiner. Reliability for this subtest is α= 89 (Monsrud & Rygvold, 2013).

Expressive vocabulary, expressive grammar, and receptive grammar measures at 6 years

Six subtests from *CELF-4* were used at age 6 years. The subtest *Expressive Vocabulary,* henceforth called ‘Expressive Vocabulary CELF 6’, was re-administered to measure children’s vocabulary skills. The subtests *Word Structure, Formulated Sentences, and Recalling Sentences,* were re-administered to assess children’s expressive grammar skills. The scores from these three subtests were standardized and then combined into a composite score henceforth called ‘Expressive Grammar CELF 6’. Cronbach Alpha reliability for this composite score is .81.

The subtest *Concepts and Following Directions* was used to evaluate the ability to interpret, recall and execute verbal instructions of increasing length and complexity that contain concepts of functional language. Here, the child points to pictured objects in response to oral directions. Reliability for this subtest is α= 94 (Monsrud & Rygvold, 2013). The subtest *Sentence Structure* was used to evaluate the ability to understand grammatical rules at the sentence level. Here, the child responds to a sentence by pointing to the correct picture stimuli. Reliability for this subtest is α= 74 (Monsrud & Rygvold, 2013). The *Concepts and Following Directions* and the *Sentence Structure* scores were standardized and then combined into a composite score henceforth called 'Receptive Grammar CELF 6'. Reliability for this composite score is α= .81.

Defining risk of developmental language disorder at 6 years

Classification of children's language status at 6 years was based on their *CELF-4 Core Language* score, which is derived by summing the scaled scores from the following four subtests, *Word Structure*, *Formulated Sentences*, *Recalling Sentences*, and *Concepts and Following Directions*, and is standardized around a mean of 100 and a standard deviation of 15. The CELF-4 Core Language score is a representative measure of general language ability that quantifies a child's overall language performance and is used to make decisions about the presence or absence of DLD (Monsrud & Rygvold, 2013). Reliability for the CELF-4 Core Language scale is α= 92 (Monsrud & Rygvold, 2013).

In a manner similar to Snowling et al. (2016), and Carroll and Myers (2010), a cut-off of language impairment corresponding to a score 1 *SD* below the mean (i.e., ≤85) for the normative population was adopted. Also, in accordance with St Clair et al.'s (2019, p. 2754) study, we adopted the term 'risk of DLD' instead of the diagnostic label of DLD when referring to language difficulties in children at age 6 years. This is also in line with the consensus that although test scores provide useful information they should not be used as the sole criterion for identifying DLD (Bishop, 2017). Based on this cut-off point (i.e., ≤85), 9 out of 24 children in the FR group and 3 out of 22 children in the NoFR group were classified as being at risk of DLD at age 6 years.

Research design and general procedure

All children were tested individually at ages 2, 4;6, and 6 years, ± 3 weeks. Thus, they were the same age at all time points. Assessments were administered in a laboratory at the university and were videotaped and audio-recorded for later analyses. Each session lasted 2-3 hours and was completed with one examiner and one parent in the room (i.e., up to the age of 4;6 years). Parents received and completed the CDI form regarding their child's expressive vocabulary and grammar at home a day or two before the visit to the university laboratory. The CDI forms were inspected by the examiners at the clinic to identify possible errors.

Results

All distributions of continuous language measures were normal or close to normal and no extreme values were detected in Box Plot analyses. Therefore, no transformations of measures or moving of outliers were necessary. FR status was coded as follows: 1 = FR and 0 = no FR. Likewise, the dichotomous LT status was coded as follows: 1 = LT and 0 = no LT.

Group comparisons in language outcomes at ages 4;6 and 6 years

Our first research question was related to possible effects of FR status and LT status on vocabulary and grammar outcomes at ages 4;6 and 6 years. Descriptive statistics for the four groups in language skills at 4;6 and 6 years are presented in Table 2. The effects of FR and LT statuses were examined using multivariate analyses of variance (MANOVA) with FR status and LT status as the independent measures and expressive vocabulary, receptive grammar, and expressive grammar as the dependent measures. Separate analyses were performed for the two outcome ages, 4;6 and 6 years. At both ages, covariance matrices were equal based on Box Test of Equality of Covariance Matrices ($F(18, 1303.83) = 0.92$, $p = .55$, and $F(18, 1273.79) = 0.88$, $p = .60$, 4;6 and 6 years, respectively).

Age 4;6 years outcome. At 4;6 years, the main effect of LT status was significant ($F(3, 39) = 5.30$, $p < .01$, $\eta_p^2 = .29$), whereas the effect of FR of dyslexia was not ($F(3, 39) = 2.07$, $p = .12$, $\eta_p^2 = .14$). No FR x LT status interaction was found either ($F(3, 39) = 0.95$, $p = .54$, $\eta_p^2 = .05$).

The univariate analyses of variance (ANOVA) test of between-subject effects showed further that LTs scored significantly lower in Expressive Grammar at 4;6 years compared to NoLTs (see Table 3), but not in Expressive Vocabulary or Receptive Grammar at 4;6 years. Effect size (see Table 4) between these two groups was large in expressive grammar, moderate in receptive grammar and small in expressive vocabulary. In addition, moderate effect size was found between FR and NoFR groups in expressive vocabulary and expressive grammar.

Age 6 years outcome. Both main effects, FR status and LT status, were significant in multivariate analyses of variance (MANOVA) concerning language skills at 6 years (F(3, 40) = 4.58, p < .01, η_p^2 = .26 and F(3, 40) = 7.06, p< .001, η_p^2 = .35, respectively), whereas the FR x LT status interaction was not (F(3, 40) = 0.99, p = .94 η_p^2 = .01). The test of between-subject effects showed, first, that children with FR of dyslexia scored lower than children without such a risk in Expressive Grammar at 6 years (see Table 3). Moreover, LTs scored significantly lower in Expressive Grammar at 6 years compared to NoLTs. Effect sizes were large in expressive grammar in both two-group comparisons, i.e. FR vs. NoFR and LT vs. NoLT (see Table 4). No differences were found between the FR and NoFR groups in Expressive Vocabulary or Receptive Grammar at 6 years. Likewise, no differences were found between the LT and NoLT groups in Expressive Vocabulary or Receptive Grammar at 6 years either. Moderate effect size was found in expressive vocabulary between the two FR groups. All other effect sizes were small.

Describing language outcomes at 6 years. We further examined the proportions of children in the current sample who were at risk of DLD at the age 6 follow-up. Two of the six (33%) FR children identified as LTs at age 2 years showed typical language by performing within normal limits (i.e., >85) on the 6-year CELF-4 Core Language scale. The remainder four out of the six (67%) late talking children in the FR group obtained standard scores ranging from 58 to 72, with a mean of 63.75. They were accordingly defined as at risk of DLD. The 6-year CELF-4 Core Language scale identified an additional five children in the FR group (28%) who were not identified as LTs at 2 years, but obtained scores ≤85 at age 6 years. The standard scores of these children were between 77 and 85, with a mean score of 80.08. Hence, they were also at risk of DLD. However, in comparison with their peers who had poor expressive vocabulary at age 2 years and had persistent language problems at age 6 years, these children had normal vocabulary skills at age 2 years, but had language problems at age 6 years. We thus refer to this profile as emerging DLD in the remainder of the paper.

In the NoFR group, three of the six LTs (50%) performed within normal limits on the CELF-4 Core Language scale, whereas the other three children (50%) were at risk of DLD. The standard scores of the children at risk of DLD were between 46 and 82 and the mean score was 64.33. In the NoFR group, none of the children with typical expressive vocabulary at age 2 years had emerging DLD at 6 years. These results must be interpreted with caution though because the number of children is small.

Predicting language outcomes at age 6 years

In our second research question, we examined how much of the variability in expressive vocabulary, and receptive and expressive grammar at age 6 years was explained by children's group statuses and earlier language skills assessed at age 4;6 years. We also examined whether FR status moderated the relationship between 4;6 and 6 years language skills. To answer these questions, we performed three separate hierarchical linear regression analyses having Expressive Vocabulary, Receptive Grammar and Expressive Grammar at 6 years as the dependent measure, at a time. We examined the effect of 1) FR status and LT status, 2) the 4;6-year language skills, and 3) FR status x the 4;6-year language skills interaction effects on age 6 years language outcomes (separate analysis for each of the 6-year language outcome). The independent measures were entered into the model as follows: In the first step, the dichotomous FR status and LT status were entered. In the second step, the 4;6-year measure of the outcome language skill was entered (e.g., expressive vocabulary at 4;6 years when predicting the 6-year expressive vocabulary). Finally in the third step, an interaction measure FR status x the 4;6 year language skill was entered into the model to see whether the effect of previous language skills varied according to the FR status. No serious multicollinearity between the independent measures was detected (VIF values ranged from 1.01 to 3.04). In addition, in all regression analyses the residuals were distributed normally. Pearson correlations between all language measures separately for the whole sample, the FR group, and the NoFR group, are available through the online appendix.

Expressive vocabulary. Altogether 24% of the variance in Expressive Vocabulary at age 6 years could be explained by the predictors (see Table 5a). Only the 4;6-year measure of expressive vocabulary predicted significantly expressive vocabulary at 6 years when entered into the model at the second step (std $\beta = .43^{**}$). However, the effect of Expressive Vocabulary at 4;6 years changed to be nonsignificant when the FR status x Expressive Vocabulary 4;6 years interaction term was entered into model in the final step, that is, none of the predictors were significant when all the independent predictors were entered into the model.

Receptive grammar. Likewise, 27% of the variance in Receptive Grammar at 6 years was explained, Receptive Grammar at 4;6 years being the only significant predictor when entered into the model in the second step (std $\beta = .52^{***}$) (see Table 5b). Contrary to predicting Expressive Vocabulary at 6 years, it remained significant even when the FR status x Receptive Grammar at 4;6 years interaction measure was entered into the model at step three.

Expressive grammar. Finally, altogether 72% of the variance in Expressive Grammar at 6 years could be predicted by the independent measures (see Table 5c). FR status, Expressive Grammar at 4;6 years, and FR status x Expressive Grammar at 4;6 years interaction effect were significant predictors of expressive grammar at 6 years in the final model. Having FR of dyslexia decreased the score in expressive grammar at 6 years by .20 standard deviation compared to children without FR. Expressive Grammar at 4;6 years had a positive relation to Expressive Grammar 1.5 years later; the better the skill at 4;6 years, the better it was at 6 years. However, also the FR status x Expressive Grammar at 4;6 years interaction effect was significant. Further hierarchical linear regression analyses separately in the FR and NoFR groups showed that the effect of Expressive Grammar at 4;6 years on Expressive Grammar at 6 years was larger in the FR group compared to the NoFR group (std β = .81*** and .67**, FR and NoFR group, respectively).

Discussion

The aim of this study was to examine the potential effects of familial risk of dyslexia and late talking, respectively, on subsequent language abilities and the possible interaction effect between these two risk factors. We followed a group of FR and NoFR children from 24 months through age 4;6 to 6 years. We examined expressive vocabulary as well as expressive and receptive grammar separately to provide a comprehensive picture of long-term language outcomes in these children. We found a significant effect of LT status on language both at ages 4;6 and 6 years. We also found that FR status had an impact on expressive language skills at age 6 years rather than at 4;6 years. The interaction between LT and FR statuses was not significant, implying that late talking children achieved lower scores, regardless of their FR status. We observed that some of the FR children (but none in the NoFR group) with typical expressive vocabulary skills at age 2 years appeared to have emerging DLD at the age 6 follow-up.

Furthermore, the regression model showed that the 4;6-year language measures together with LT and FR statuses could explain more of the variation in expressive grammar than in vocabulary and receptive grammar at age 6 years. A significant moderating effect of FR status was found on the association between the 4;6-year and the 6-year expressive grammar skills; the predictive power of 4;6 years skill was larger in the FR group.

Effect of late talker status and FR status on language skills

The current results indicate that the LT group performed significantly poorer on expressive grammar at both 4;6 and 6 years, suggesting that this particular domain of language poses a greater risk for long-term problems in this group of children. On the other hand, LTs' performance in expressive vocabulary and receptive grammar were comparable to their NoLT peers at both ages. These findings corroborate with previous research showing that although LTs, as a group, continue to lag behind their typically developing peers on expressive grammar skills throughout the preschool years, they perform within age expectations on vocabulary and receptive grammar by age 6 years (e.g., Ellis & Thal, 2008; Moyle et al., 2011; Paul et al., 1997; Rescorla, 2011; Rescorla & Turner, 2015; Rice et al., 2008). Furthermore, five of the twelve late talking children with and without FR showed age-appropriate language skills, while the remainder of them (i.e., seven children) were at risk of DLD by the time they entered school (i.e., 6 years), in agreement with previous research (Paul & Ellis Weismer, 2013). Socioeconomic status has been reported as one of the most robust correlates of later language challenges in LTs (Armstrong et al., 2017; Reilly et al., 2010). It might thus explain the variability in the rate of recovery from early language delay among LTs with and without FR. However, in the present study there were no differences between the groups in terms of their household income, suggesting that this variable is not likely to account for the current group differences.

Our data also revealed that despite having typical expressive vocabulary at age 2 years, five children in the FR group appeared to have emerging DLD at age 6 years. This suggests that FR status might include other language-related risk factors (e.g., deficits in perception and segmentation of early speech; Lohvansuu et al., 2018; Snowling, Lervåg et al., 2019), which are not covered by the early vocabulary measure, but resulted in language difficulties at a later age. However, due to low number of FR children who seemed to have emerging DLD, this result should be considered preliminary. Reporting a similar finding in their longitudinal study with a larger FR sample (N = 75), Snowling and colleagues (2016) argue that this particular result might be suggestive of a different aetiology, possibly of genetic origin, which leads to atypical language trajectories seen in some FR children. More research following FR children from toddlerhood into school years may contribute to gaining more insight into the rate and pattern of language growth in this group of FR children, who seem to start in the normal range for language but fall in the impaired range at a later time point in childhood.

Furthermore, our results indicated that FR status had an effect on expressive language skills more clearly at age 6 years, but not so much at 4;6 years. A plausible explanation of this finding might be related to our observation that a number of FR children who were not classified as LTs at age 2 years appeared to have emerging DLD at 6 years. In other words, these children with emerging DLD probably pulled down the mean level of the FR group at this age. However, it should also be mentioned that we found moderate effect sizes for between-group on both expressive vocabulary and expressive grammar at age 4;6 years. This might be suggestive of a decreasing trend in language skills in the FR group as a whole in the period from age 2 to 6 years, which became most apparent by the age of 6 years. A similar pattern of results has also been reported in a recent study by Snowling, Nash et al. (2019), which found that oral language deficits in English FR children diagnosed with dyslexia increased with age and became large after school entry. Likewise, van Viersen et al. (2018) reported that despite a number of differences detected on language measures between Dutch FR and NoFR groups, the effect sizes were larger for FR children who later developed dyslexia. In summary, it is evident that language deficits are more often identified in FR children diagnosed with dyslexia, regardless of their mother tongue (e.g., English: Carroll et al., 2014; Finnish: Torppa et al. 2010; Dutch-speaking: van Viersen et al., 2017) and that the proportion of these children varies greatly across FR samples (approx. 29-66%, Snowling & Melby-Lervåg, 2016). Therefore, detecting a significant effect of FR status on oral language development would essentially depend on the number of FR children with dyslexia in a given sample.

On the basis of the findings from the studies reviewed above, it is interesting to speculate that the observed effect of FR on expressive language skills in the present study might concern only those FR children who will go on to become dyslexic readers. In other words, it might be children’s reading status (whether they become dyslexic or not) rather than their FR status which has had an impact on language development in our study. Reading status of the children in the current sample is yet unknown. A future study thus needs to establish whether this result is a reading-related or FR-related effect. Furthermore, our finding that nine FR children were also at risk of DLD suggests that the observed effect of FR on expressive language skills might mainly concern FR children, who will later be diagnosed with DLD (with or without comorbid dyslexia). It follows that the overall effect of FR on language outcomes reported here should be interpreted with great caution.

Our finding that FR did not have a main effect on language outcomes at age 4;6 years could also be due to the small sample reported here. A small sample size limits statistical power for detecting the potential differences in lexical and grammatical knowledge particularly at younger ages at the group level. This is because difficulties in these language domains are relatively more subtle than phonological processing difficulties that the majority of FR children seem to experience to varying degrees from early years on (Lohvansuu et al., 2018; Snowling, Lervåg et al., 2019; Snowling & Melby-Lervåg, 2016). In other words, the current sample size was probably too restricted to detect the small differences between FR and NoFR groups. This suggests that a larger sample is needed to be able to find a possible effect of FR on children's early lexical and grammatical development. Another concern with small sample sizes is the sample bias. As noted above, not all FR children will develop dyslexia and those who will eventually get a diagnosis form the minority of the FR group as a whole (mean prevalence 45%, Snowling & Melby-Lervåg, 2016). Thus, small samples have a higher chance of not including an adequate number of affected children, which may partly explain the non-significant differences in comparisons between only FR and NoFR children. Replication of the current study is a prerequisite to further interpret these results. Future longitudinal studies with larger FR samples will contribute to a better understanding of whether and how FR status exerts an effect on oral skills early in development.

With respect to interaction effects, our data failed to find significant interactions between LT and FR statuses, indicating that LTs had similar developmental trajectories regardless of their FR status. This result might seem unexpected based on the findings by Lyytinen et al. (2005) that LTs with FR scored significantly lower than LTs without such risk in preschool years. However, it should be noted that in the current study, LTs with FR of dyslexia achieved somewhat lower scores at both assessment points, suggesting that interaction might have become significant in a larger sample. That said, in line with our results, Carroll and Myers (2010) failed to detect interaction between the FR and the speech and language-therapy group statuses in terms of their effects on language outcomes. The authors reported though significant interactions between the two group statuses on the measures of phonological processing skills, one of the core deficits related to dyslexia. Results of the current study seem to suggest that in lexical and grammatical skills interaction effects might be harder to detect, especially when the sample size is small. Thus, if our study had included tasks assessing children's phonological abilities, we might have found that the LT group with FR scored more poorly than LTs with NoFR. This issue needs to be addressed in future studies.

Prediction of language outcomes at age 6 years

We found that performance on vocabulary and grammar at age 4;6 years was a significant predictor of the corresponding outcomes at age 6 years. This is congruent with previous evidence that the major predictor of later language status is language at an earlier age (Ellis Weismer, 2007; Henrichs et al., 2011). When the other predictors were entered into the model, the 4;6-year expressive vocabulary was no longer significant. This is probably due to overlapping variance in the dependent measure explained by both Expressive Vocabulary at 4;6 years and the interaction term FR status x Expressive Vocabulary at 4;6 years, since regression analyses tap and test the significance of unique variance of each predictor on the dependent measure. Results also indicated that the amount of variance explained by the model was much larger for expressive grammar (72%) than for expressive vocabulary (24%) and receptive grammar (27%) at age 6 years. These values appear to be higher than earlier published research, which included language skills assessed before the age of 3 years. For example, the regression model in Henrichs et al. (2011) study, including perinatal, demographic, and maternal factors together with earlier language scores explained 18% of the variance in expressive vocabulary at 30 months. 11% of this variance was explained by expressive vocabulary at 18 months. Likewise, the model in Ghassabian et al. (2014) using a similar set of predictors to that of Henrichs et al. (2011) explained 15% of the variance in receptive vocabulary at age 6 years. 0.3% and 1.5% of this variance was accounted for by receptive and expressive vocabulary at 18 months, respectively, and 2;6 years expressive vocabulary explained only 2%. There is, however, evidence of more stability in language development between ages 4 and 7 years than in the period from 2 to 4 years (Armstrong et al., 2017). Therefore, our results might be mainly due to the inclusion of language measures taken at a later age point (i.e., 4;6 years) and also due to the relatively shorter prediction period (i.e., from 4;6 to 6 years) studied in the current study.

On the other hand, the prediction model in Lyytinen et al. (2001) including FR status and earlier language skills, among others, accounted for 34% and 48% of the variance in receptive and expressive language, respectively, at 42 months. The percentage of variance explained by Lyytinen et al.'s model seems to be higher than those reported in the epidemiological studies above, and therefore, relatively more similar to the current ones. However, the outcome measures in Lyytinen et al. (2001), both receptive language and expressive language at 42 months were based on receptive vocabulary and grammar, and expressive vocabulary and grammar, respectively. In the present study, we differentiated between vocabulary and grammatical knowledge in the oral language outcomes at 6 years, suggesting that results of these two studies are not fully comparable.

Prediction studies vary greatly in terms of the ages of children and the way predictors and outcomes were defined. Consequently, their results are not directly comparable, as they do not reflect completely the same skills in children studied. Nevertheless, the present study and previous studies indicate that despite including a number of potential demographic, linguistic and environmental factors, the predictive models in these studies still leave much of the variance in later language outcomes unexplained across preschool years. This can be taken to suggest that factors that not yet addressed are influencing language progress. The fact that our model accounted for more than 70% of variance in later expressive grammar is thus noteworthy. It is also notable that both expressive grammar at age 4;6 years and FR status significantly predicted expressive grammar at age 6 years. FR status was observed to play a significant predictive role on expressive, but not on receptive language outcomes in Lyytinen et al. (2001) study as well. These results imply that expressive grammar difficulties might be related to FR of dyslexia. In addition, we found that expressive grammar at 4;6 years predicted expressive grammar at 6 years in both groups. However, FR status significantly moderated the association between the 4;6-year and the 6-year expressive grammar skills in children, suggesting that in the FR group the effect of earlier expressive grammar skill on subsequent expressive grammar was significantly larger than in the group without family history of dyslexia. A possible explanation for significantly lower expressive grammar skills in the FR group might be related to our observation that altogether nine children in this group (N = 24) were classified as being at risk of DLD. Children with DLD (with or without comorbid dyslexia) are known to display deficits particularly in semantics, syntax, discourse (Bishop & Snowling, 2004). Therefore, these results suggest that a proportion of FR children in the present study are not only at risk of dyslexia but also DLD. Moreover, their difficulties in grammar place these children at higher risk for reading comprehension problems as evidence shows that early oral skills have a direct influence on reading comprehension development (Hulme et al., 2015; Psyridou et al., 2018).

Although strengthened by a longitudinal design, there are a number of limitations to this research study. First, as noted earlier, our results are based on a small sample of children, and therefore, should be interpreted with appropriate caution. Despite being aligned with previous research, they certainly need to be validated in future studies employing larger samples. Second, the present study did not include a measure of receptive language ability at 2 years. Therefore, we were unable to determine whether the delay in language at age 2 years was limited to expressive language. LTs with early receptive language problems are reported to be more at risk for subsequent poor language outcomes. Thus, inclusion of receptive measures is recommended in future studies to gain more insight into the developmental profiles of LTs with a FR of dyslexia. Third, seven children withdrew from the study by the age of 3 years due to relocation outside the region and data from these children were not included in the analyses. This dropout did not appear to be at random though, pointing to some selective attrition. That is, the 2-year expressive vocabulary scores of excluded children were lower than those who continued in the study during the follow-up period. This may have reduced the variance of the sample and therefore the statistical power of the current analyses. That said, it is also likely that the selective drop out has decreased the differences between groups, making the current significant results relatively more convincing.

In conclusion, these preliminary findings indicate that expressive language skills, in particular expressive grammar, are compromised in children born at FR of dyslexia at the group level by school age. We cannot discern though with certainty whether this is due to children's FR status or their future reading status (dyslexic or not). The current results further suggest that language skills at age 4;6 years, in combination with the child's FR status predict the child's language outcomes at 6 years, and may serve as an index of need for additional support. It is not straightforward though to translate current results into clinical practice for use at the individual level, as they are based on group means. However, they clearly point to the importance of considering not only early language skills but also whether the child has an additional risk factor, such as a family history of literacy difficulties, when deciding who might be most in need of early and sustained intervention. They also warrant that language development in at-risk children be monitored throughout preschool years and in particular before school entry to secure early identification and timely educational support during the early school years.

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Table 1

Demographic Variables of Parents at the Beginning of the Study

	FR parents (n=44)			NoFR parents (n=36)						Effect size
	Mean	*SD*	*Range*	*Mean*	*SD*	*Range*	*t*	*df*	*p*	*Cohen's d*
Age (years)	34.80	5.41	25-50	35.00	5.26	26-46	0.22	115	.827	0.04
Educational level (rating scale)	2.85	0.87	1-4	3.17	0.85	1-4	1.99	118	.049	0.37
Education after compulsory (years)	3.22	2.74	0-10	4.06	2.91	0-10	1.51	109	.133	0.29
Total household income (rating scale)	2.69	1.10	1-4	2.71	1.14	1-4	0.98	114	.922	0.18
Performance IQ (scaled scores)	118.11	11.47	89-138	120.17	8.98	99-134	0.55	74	.581	0.13

Note. FR = FR of dyslexia; NoFR = no FR of dyslexia. SD = standard deviation.

Table 2

Means and Standard Deviation in Expressive Vocabulary, Receptive and Expressive Grammar at 4;6 and 6;6 Years in the Four Groups

		FR+LT n = 6		FR+NoLT n = 18		NoFR+LT n = 6		NoFR+NoLT n = 16	
	Range	M	SD	M	SD	M	SD	M	SD
Age 4;6 years									
Expressive Vocabulary CELF	-2.02 – 1.93	-0.41	1.03	-0.21	1.03	0.32	1.10	0.39	0.85
Receptive Grammar TROG	-2.13 – 1.52	-.28	.83	0.00	1.04	-.56	0.51	.38	0.93
Expressive Grammar CELF	-1.49 – 1.82	-0.75	0.76	-0.10	0.69	-0.55	0.44	0.66	0.62
Age 6 years									
Expressive Vocabulary CELF	-1.90 – 1.86	-.30	1.31	-0.25	0.98	0.54	1.00	0.20	0.867
Receptive Grammar CELF	-1.87 – 1.50	-0.19	0.73	-0.03	1.06	0.19	0.49	0.19	0.73
Expressive Grammar CELF	-2.16 – 1.48	-0.87	1.07	-0.04	0.72	-0.00	0.79	0.73	0.47

Note. FR = FR of dyslexia; LT = late talker; NoLT = no late talker; NoFR = no FR of dyslexia; CELF = The Clinical Evaluation of Language Fundementals-4; TROG = The Test for Reception of Grammar-2; SD = standard deviation.

All measures reported in z-scores. Expressive Grammar at 4;6 years as well as Receptive Grammar at 6 years and Expressive Grammar at 6 years are average means from three standardized test scores.

Table 3

Pairwise Group (FR and Late talker statuses) Comparisons in Expressive Vocabulary, Receptive Grammar and Expressive Grammar at 4;6 and 6 years

	FR status			LT status			Pairwise group comparisons [a)]
	df	F	η_p^2	df	F	η_p^2	
Age 4;6 years							
Expressive Vocabulary				(1, 41),	0.08	.002	
Receptive Grammar				(1, 41)	2.60	.06	
Expressive Grammar				(1, 41)	12.11**	.23	LT < NoLT
Age 6 years							
Expressive Vocabulary	(1, 41)	3.70	.08	(1, 41)	0.21	.005	
Receptive Grammar	(1, 41)	1.05	.02	(1, 41)	0.07	.002	
Expressive Grammar	(1, 42)	11.82***	.22	(1, 42)	10.81*	.20	FR < NoFR, LT < NoLT

Note. FR = FR of dyslexia; LT = late talker; NoLT = no late talker; NoFR = no FR of dyslexia

[a)] Group differences are significant at least at $p < .05$

N = 42 or 43 depending on missing values in separate measures.

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

Table 4

Effect Sizes between 1) the Two FR Groups and 2) the Two Late talker Groups

	FR (n = 24) vs. No FR (n = 22)	Late talker (n = 34) vs. No late talker (n = 12)
Age 4;6 years		
Expressive Vocabulary	**0.59**	0.10
Receptive Grammar	0.10	**0.61**
Expressive Grammar	**0.64**	**1.21**
Age 6 years		
Expressive Vocabulary	**0.57**	0.15
Receptive Grammar	0.31	0.09
Expressive Grammar	**1.01**	**0.87**

Note. Effect sizes were estimated with Cohen's *d* (computed with pooled standard deviations). Effect sizes larger than 0.5 in bold.

Table 5a

Summary of Hierarchical Linear Regression Analysis Predicting Expressive Vocabulary at 6 years (n = 43)

	Expressive vocabulary			
Predictor	ΔR^2	β	b (Se)	95% CI for b
Step 1: grouping	.08			
FR status		-.14	-.65 (.70)	-2.01 – 0.77
Late talker status		.10	.52 (.75)	-1.01 – 2.04
Step 2: previous language skill	.16**			
Expressive Vocabulary 4;6 years		.42	.44 (.23)	-0.03 – 0.91
Step 3: interaction effect	.00			
FR status x Expressive Vocabulary 4;6 years		.01	.04 (.71)	-1.40 – 1.48
Total R^2 / Adjusted R^2	.24 / .16			
Model fit	F(4, 39)=3.11*			

Note. Standardized beta-values (β) and unstandardized beta-values together with standard errors (b (Se)) presented according to the final model with all independent measures included into the model.

CI = Confidence interval.

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

Table 5b

Summary of Hierarchical Linear Regression Analysis Predicting Receptive Grammar at 6 years (n = 43)

	Receptive grammar			
Predictor	ΔR^2	β	b (Se)	95% CI for b
Step 1: grouping	.03			
FR status		-.10	-.16 (.23)	-0.62 – 0.31
Late talker status		.11	.21 (.28)	-0.35 – 0.77
Step 2: previous language skill	.25***			
Receptive Grammar 4;6 years		.52*	.03 (.01)	0.01 – 0.05
Step 3: interaction effect	.00			
FR status x Receptive Grammar 4;6 years		-.00	-.00 (.25)	-0.51 – 0.50
Total R^2 / Adjusted R^2	.27 / .20			
Model fit	F(4,39)=3.63*			

Note. Standardized beta-values (β) and unstandardized beta-values together with standard errors (b (Se)) presented according to the final model with all independent measures included into the model.

CI = Confidence interval.

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

Table 5c

Summary of Hierarchical Linear Regression Analysis Predicting Expressive grammar at 6 years (n = 43)

	Expressive grammar			
Predictor	ΔR^2	β	b (Se)	95% CI for b
Step 1: grouping	.37***			
FR status		-.20*	-.34 (.16)	-0.67 – -0.02
Late talker status		-.07	-.13 (.20)	-0.54 – 0.27
Step 2: previous language skill	.31***			
Expressive Grammar 4;6 years		.49**	.51 (.15)	0.20 – 0.82
Step 3: interaction effect	.04*			
FR status x Expressive Grammar 4;6 years		.29*	.37 (.15)	0.06 – 0.68
Total R^2 / Adjusted R^2	.72 / .69			
Model fit	F(4,39)=25.47***			

Note. Standardized beta-values (β) and unstandardized beta-values together with standard errors (b (Se)) presented according to the final model with all independent measures included into the model.

CI = Confidence interval.

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

ONLINE APPENDIX: Tables 1a, 1b, 1c

Table 1a *Pearson correlations between language measures at 2;0 4;6 and 6;0 within the whole sample (n=44-46)*

	2.	3.	4.	5.	6.	7.	8.	9.
1. Expressive Vocabulary 2;0	.08	.33*	.46**	-.11	.25	.45**	.07	-.69***
2. Expressive Vocabulary 4;6		.48***	.53***	.46**	.44**	.61***	-.32*	-.06
3. Receptive Grammar 4;6			.49***	.01	.50***	.53***	-.11	-.29
4. Expressive Grammar 4;6				.35*	.38*	.81***	-.37*	-.51***
5. Expressive Vocabulary 6;0					.28	.45**	-.28	.07
6. Receptive Grammar 6;0						.60***	-.15	-.04
7. Expressive Grammar 6;0							-.45**	-.39**
8. FR status								-.03
9. LT status								

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

Table 1b *Pearson correlations between language measures at 2;0 4;6 and 6;0 within the FR-group (n=22-24)*

	2.	3.	4.	5.	6.	7.
1. Expressive Vocabulary 2;0	.12	.23	.47	.05	.41*	.58**
2. Expressive Vocabulary 4;6		.44*	.65**	.41	.61**	.54**
3. Receptive Grammar 4;6			.46*	.04	.49*	.47*
4. Expressive Grammar 4;6				.52*	.69***	.85***
5. Expressive Vocabulary 6;0					.32	.52**
6. Receptive Grammar 6;0						.73***
7. Expressive Grammar 6;0						

Note. FR = family risk of dyslexia.

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

Table 1c *Pearson correlations between language measures at 2;0 4;6 and 6;0 within the NoFR group (n=22)*

	2.	3.	4.	5.	6.	7.
1. Expressive Vocabulary 2;0	.09	.51*	.62**	-.34	-.04	.48*
2. Expressive Vocabulary 4;6		.51*	.27	.42*	.23	.59**
3. Receptive Grammar 4;6			.52*	-.08	.51*	.66***
4. Expressive Grammar 4;6				.01	.07	.70***
5. Expressive Vocabulary 6;0					.14	.13
6. Receptive Grammar 6;0						.32
7. Expressive Grammar 6;0						

Note. NoFR = no family risk of dyslexia.

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

Study III

Caglar-Ryeng, Ø., Eklund, K., & Nergård-Nilssen, T. (2019). The effects of book exposure and reading interest on oral language skills of children with and without a familial risk of dyslexia.

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The effects of book exposure and reading interest on oral language skills of children with and without a familial risk of dyslexia

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Keywords: dyslexia, at-risk, vocabulary, grammar, home literacy environment

Abstract

The potential role of home literacy environment (HLE) in children's language development has been widely studied. However, data on the HLE of children with familial risk (FR) of dyslexia are limited. In this longitudinal study, we examined a) whether amount of book exposure and reading interest at age 4 were different in samples of Norwegian FR and no FR-children, respectively, b) whether these home literacy-related factors exerted different effects depending on family-risk status on vocabulary and grammar skills at school entry age (6 years), and c) whether they contributed independently to language outcomes at age 6, after controlling for the 4;6-year language skills. Results showed no significant between-group differences in book exposure and reading interest. Furthermore, while interest in reading did not affect vocabulary and grammar in either group, book exposure contributed to vocabulary skills only in the FR-group by school entry. However, this longitudinal association was mediated by lexical skills at age 4;6, implying that the HLE has a positive indirect effect on later language development through its effect on early language. Thus, these findings can be taken to suggest that early intervention including exposure to various book-reading activities for preschool FR-children with poor expressive vocabulary is worth considering.

Keywords: dyslexia, at-risk, vocabulary, grammar, home literacy environment

The effects of book exposure and reading interest on oral language skills of children with and without a familial risk of dyslexia

Parents and the home literacy environment (HLE) they create are considered to have an important role in the development of children's language and literacy skills, and understanding fully the role of HLE is of continued interest (e.g., Bus, Van Ijzendoorn, & Pellegrini, 1995; Frijters, Barron, & Brunello, 2000; Grolig, Cohrdes, Tiffin-Richards, & Schroeder, 2019; Niklas & Schneider, 2017). The 'home literacy environment' usually refers to the experiences, attitudes, and materials related to literacy that a child encounters and interacts with at home (Roberts, Jergens, & Burchinal, 2005). Despite the extensive research attention that the HLE has attracted, data on the home literacy environment of children with a family history of dyslexia are scarce (Snowling & Melby-Lervåg, 2016) and mixed. While some studies report differences between the HLE experienced by children at family risk of dyslexia compared with those not at risk (e.g., Dilnot, Hamilton, Maughan, & Snowling, 2017; Scarborough, 1991), other studies report no difference (e.g., Elbro, Borstrøm, & Petersen, 1998; Torppa et al., 2007; van Bergen, de Jong, Maassen, & van der Leij, 2014). The current study attempts to fill this void by examining the relationship between HLE and language development in a sample of preschoolers at familial risk (FR) of dyslexia in comparison to a control group with no family risk (NoFR). More specifically, by considering whether FR-status serves as a moderating factor in this relationship, we investigate to what extent home literacy practices assessed at age 4 could predict broader oral language skills (i.e., vocabulary and grammar) around the time of school entry (age 6) in children with and without FR.

The concept of home literacy environment has been operationalised using a variety of indicators, which are not consistent across studies (Schmitt, Simpson, & Friend, 2011). In a key study, Sénéchal and LeFevre (2002) have suggested that home-based literacy experiences that children are exposed to can be conceptualised into two broad categories as ‘formal’ and ‘informal’ activities. Formal literacy activities include shared parent-child focus on the print per se by, for example, talking about letter names and the corresponding sounds. Informal literacy activities, on the other hand, include shared focus on the meaning contained in the print. For example, during book reading, the parent may explain the moral of the story and the child may ask about the meanings of certain words (Sénéchal & LeFevre, 2002). Whereas formal home literacy experiences in the preschool years have been shown to be related to emergent literacy skills such as letter knowledge, decoding and word recognition (Hood, Conlon, & Andrews, 2008; Torppa, Poikkeus, Laakso, Eklund, & Lyytinen, 2006), informal home literacy experiences appear to be associated with children’s oral language development and comprehension skills (Mol, Bus, De Jong, & Smeets, 2008; Sénéchal & LeFevre, 2002; Sénéchal, Pagan, Lever, & Ouellette, 2008). In the present study, we focused on the informal aspect of the HLE, as our main objective was to examine its developmental relationship with children’s lexical and grammatical skills before entry to formal schooling. We assessed four components of the HLE, which we categorized as book exposure: frequency of shared reading, parent as a role model for reading, access to books, and number of books in the home. In addition, we measured child’s own interest in book reading, another factor that is related to home literacy practices and may contribute to children’s language skills (Hume, Lonigan, & McQueen, 2015; Scarborough & Dobrich, 1994). Of particular interest was whether oral language skills in FR and NoFR groups developed similarly as a function of variation in these two home-literacy related constructs.

The relationship between book exposure and vocabulary and grammar development

Book exposure is a general term used to describe the overall exposure to informal home literacy practices and usually measured by factors such as frequency of parent-child shared reading, number of books owned, access and exposure to literacy materials, and visits to the library (Payne, Whitehurst, & Angell, 1994; Phillips & Lonigan, 2009; Sénéchal, 2006; Sénéchal & LeFevre, 2002). Positive effects of book exposure on growth in oral language skills have been widely reported, especially in vocabulary (Deckner, Adamson, & Bakeman, 2006; Farrant & Zubrick, 2013; Schmitt et al., 2011; Sénéchal & LeFevre, 2001; Zhang et al., 2018). It has been suggested that book exposure practices, in particular shared reading, promote word learning by exposing children to more linguistically complex language and varied vocabulary compared to language typically used during regular interactions such as mealtime and playtime (Evans & Shaw, 2008; Montag, Jones, & Smith, 2015). In a meta-analysis, Bus et al. (1995) found that the amount of shared reading explained about 8% of the variance in language and literacy growth of typically developing preschoolers. The findings from other meta-analyses have confirmed the significant relationship between book exposure and children's vocabulary development regardless of socioeconomic status (SES; Flack, Field, & Horst, 2018; Mol et al., 2008; Mol, Bus, & de Jong, 2009). Furthermore, there is evidence that home literacy environment has stronger effects on children's oral language skills early in development when various language skills are emerging than later when children are 4 to 5 years old and beyond, suggesting that earlier home-based literacy interactions might be relatively more influential (Mol et al., 2008; Rodriguez & Tamis-LeMonda, 2011).

A number of studies, however, have failed to find a relationship between book exposure and the development of lexicon, showing that parent report of reading-related activities do not predict language outcomes (Aram, 2006; Debaryshe, 1995; Dodici, Draper, & Peterson, 2003; Evans, Shaw, & Bell 2000; Roberts et al., 2005; Weigel, Martin, & Bennett, 2006). For example, in interpreting their null finding, Evans et al. (2000) contend that parent-child shared reading, which is not coached (e.g., in dialogic book reading style), does not significantly advance vocabulary over and above everyday experiences and discourse in typically developing children. In a similar vein, a recent meta-analysis (Noble et al., 2019) found only a small overall effect of shared reading on typically developing children's language skills, and this effect was negligible in studies with active control groups and near zero with follow-ups.

Studies on the relationship between book exposure and grammar are not only fewer but also provide less consistent findings than studies on the relationship between book exposure and vocabulary (Grolig et al., 2019; Noble, Cameron-Faulkner, & Lieven, 2018). Some studies failed to find a significant relationship between book exposure and grammar (Debaryshe, 1993; Roberts et al., 2005; Scarborough & Dobrich, 1994; Sparks & Reese, 2013). However, it has also been proposed that exposure to books provides children with models of contextually clear morphology together with complex sentence patterns, and therefore promotes grammatical processing (Cameron-Faulkner & Noble, 2013; Sénéchal et al., 2008). In support of this proposition, results from Grolig et al. (2019) study revealed that preschoolers' book exposure was a unique predictor not only of vocabulary but also of grammar. Likewise, in their study, Sénéchal et al. (2008) showed that shared reading accounted for unique variance in expressive vocabulary and morphological knowledge in 4-year-old-children. However, shared reading failed to predict syntactic knowledge. Interestingly, it was parent's own level of literacy that explained unique variance in children's syntax skills. This result points to the possibility that the link between home literacy activities and grammar can be instead genetically mediated due to the fact that parents and children not only share aspects of environment but also genes. Indeed, there is evidence that whereas vocabulary tends to be driven more by shared environment, syntax is driven more by genes in the first years of life; however, genetic factors associated with both language skills become increasingly more influential than environmental factors across development (Hart et al., 2009; Hayiou-Thomas, Dale, & Plomin, 2012; Mimeau et al., 2018). In line with this evidence, a scientific report by the National Center for Family Literacy (2008), which has synthesized the data on early literacy development concluded that exposure to books had less impact on grammar than on vocabulary.

Child interest in book reading and vocabulary and grammar skills

Child's interest in reading generally refers to enjoyment and frequency of participation in specific activities related with books (Baroody & Diamond, 2013). Fewer studies have examined the impact of reading interest on preschool children’s language and literacy acquisition (Hume et al., 2015; Sparks & Reese, 2013) in comparison with research considering the role of informal literacy interactions in language development. A review by Scarborough and Dobrich (1994) estimated that child interest could account for about 14% of the variance in language and literacy outcomes, suggesting that individual differences in interest in book reading may also contribute to language development. However, the relationship between children’s reading interest and oral language skills is not clear, with some studies finding that there is a link (Bracken & Fischel, 2008; Crain-Thoreson & Dale, 1992; Deckner et al., 2006; Lonigan, Anthony, & Burgess, 1995), whereas other studies failing to do so (Frijters et al., 2000; Roberts et al., 2005; Sénéchal, LeFevre, Thomas, & Daley, 1998; Sparks & Reese, 2013; Weigel et al., 2006). For example, Deckner et al. (2006) showed that children’s interest at age 27 months was significantly associated with expressive language at 30 months. Similarly, Crain-Thoreson and Dale (1992) found that the level of interest in reading at age 2 years predicted expressive vocabulary and syntactic comprehension in children 6 months later. Bracken and Fischel (2008) also found a positive correlation between children's reading interest and receptive vocabulary skills at 4;6 years. However, the predictive value of reading interest was not significant, when parent's education and parent-child reading interaction were taken into account. In their longitudinal study, Roberts et al. (2005) showed that child interest in book reading was not significantly related to expressive and receptive language in children at kindergarten entry (age 5 years). Likewise, interest in books was not associated with either receptive or expressive vocabulary in Sparks and Reese's (2013) study. Differences between findings could be due, in part, to the variability in the measures used to assess children's interest in reading-related activities (e.g., parent-report: Bracken & Fischel, 2008; Roberts et al., 2005; child-report: Frijters et al., 2000; direct observation: Deckner et al., 2006). That said, an interesting point to note here is that many of these studies, despite focusing on different age ranges, have provided evidence for a positive link between children's level of exposure to books and their interest in book reading (e.g., Bracken & Fischel, 2008; Crain-Thoreson & Dale, 1992; Hume et al., 2015; Roberts et al., 2005; Sénéchal et al., 1998; Weigel et al., 2006). This suggests that these two constructs may be developmentally related with one another.

The role of home literacy environment in FR children's oral language skills

Dyslexia is widely recognized as a complex multifactorial language based disorder with numerous genes implicated that interact not only with one another but also with the environment (Bishop, 2009; Pennington, 2006). The prevalence of dyslexia is considerably elevated in children with a first-degree relative with reading problems (Pennington & Lefly, 2001; Snowling & Melby-Lervåg, 2016). Research on FR children has shown that despite having impairments primarily in the phonological domain, these children, as a group, tend to score lower than their NoFR peers on tasks assessing wider oral language skills, including vocabulary and grammar, in the preschool years (e.g., XXX, 20XX; Gallagher, Frith, & Snowling, 2000; Lyytinen & Lyytinen, 2004; van Viersen et al., 2018). Compared to their typically developing peers, the potential effects of home literacy-related factors on FR children's oral language skills have been investigated to a lesser extent (Hamilton, Hayiou-Thomas, Hulme, & Snowling, 2016; Snowling & Melby-Lervåg, 2016). In an early study, Scarborough, Dobrich and Hager (1991) reported that FR children, who were later diagnosed with dyslexia, were read to less frequently by their parents in the preschool period, compared to at-risk children who did not develop reading problems. Scarborough et al. (1991) further reported that when they were 3- and 4-year-olds, FR children, who turned out to be poor readers, were less likely to look at books alone than FR children who became normal readers. However, other longitudinal studies that compared early home literacy environment of FR children with and without dyslexia found no difference between these children in terms of frequency of shared reading, access to print materials, interest in book reading, or library membership, indicating that factors impacting on the outcome of dyslexia are less likely to be environmental in origin (Elbro et al., 1998; Torppa, Eklund, van Bergen, & Lyytinen, 2011; van Bergen et al., 2011; van Bergen et al., 2014).

In a similar vein, a series of studies conducted with Finnish-speaking FR and NoFR children reported no differences between the two groups in terms of their interest in shared reading measured at age 14 months (Laakso, Poikkeus, & Lyytinen, 1999) and 24 months (Laakso, Poikkeus, Eklund, & Lyytinen, 2004). Moreover, early interest in books similarly predicted FR and NoFR children's language at age 18 months (the language score here was a composite of receptive and expressive vocabulary and grammar). However, shared reading at 24 months appeared to predict children's global language score at age 3;6 years only in the NoFR group, suggesting that children with and without family risk might benefit differently from early experiences with books, and that at-risk children may require a longer period of exposure in order to show the benefits (Laakso et al., 2004). However, another study conducted on the same sample between the ages of 2 and 6 years found that although there were no group differences in reading interest or in other aspects of the HLE, the associations of shared reading with children's reading interest and vocabulary skills were stronger in the FR group (Torppa et al., 2007).

Likewise, Hamilton et al. (2016) showed that storybook exposure at the age of 4 years predicted oral language (a composite score of vocabulary and grammar) at age 5 years in English-speaking children with and without a family risk of dyslexia. However, in contrast to previous research (e.g., Elbro et al., 1998; Torppa et al., 2007), Hamilton et al. found less exposure to books in FR children compared to their NoFR peers. The authors argued that because storybook reading varies with family SES, this observed difference might be due to the lower SES of the FR families compared to the NoFR families. The similar level of parental education (an index of SES) in FR and NoFR families in earlier studies might thus have led to differing results. Interestingly, a longitudinal study on FR children by Puglisi, Hulme, Hamilton, and Snowling (2017) found that while variation in book exposure at age 4;6 years was a significant predictor of children's language skills one year later, controlling for maternal language ability removed this effect. On this background, Puglisi et al. (2017) proposed that parental language skills, rather than shared reading per se, may have the causal effect on child language development and that the informal home literacy environment could be interpreted as a proxy for genetic effects.

In summary, although several studies have examined the potential importance of various aspects of home literacy environment and child's own interest in reading for language development in both at-risk and typical children, the extant literature is not conclusive. Moreover, since most research addressing this issue has a focus on vocabulary rather than grammar skills, examining whether book exposure and reading interest have a similar impact on these two language constructs may inform our understanding of the association between HLE and language development. In the present study, we investigated whether interest in reading and the amount of book exposure predicted variation in vocabulary and grammar in Norwegian-speaking FR and NoFR children, respectively. Our research questions were as follows:

1. Do children with and without a family risk for dyslexia differ in their book exposure or interest in reading at age 4 years? Some studies (e.g., Dilnot et al., 2017; Hamilton et al., 2016) suggest significant differences in HLE experienced by FR and NoFR children due to different socio-economic backgrounds. In line with this, studies comparing FR and NoFR children with similar socio-economic backgrounds find no differences in HLE (e.g., Elbro et al., 1998; Torppa et al., 2007). In the present study, FR and NoFR families did not differ in terms of their household income, and, FR and NoFR mothers had a similar level of maternal education. Therefore, we did not expect to find any between-group differences in book exposure or interest in reading.

2. Does family risk, book exposure, and child's own interest in reading, respectively, have an effect on expressive vocabulary and expressive grammar at age 6 years? If so, does book exposure, and, interest in reading have different effect in children with and without family risk of dyslexia? On the basis of prior research (e.g., Gallagher et al., 2000; Lyytinen & Lyytinen, 2004; van Viersen et al., 2018), we anticipated lower scores in the FR group compared to the NoFR

group. We also hypothesized that book exposure rather than reading interest might influence vocabulary (e.g., Sénéchal & LeFevre, 2002; Torppa et al., 2007), but not grammar skills (e.g., National Center for Family Literacy, 2008; Sparks & Reese, 2013). Furthermore, based on earlier findings (e.g., Moll et al., 2008; Rodriguez & Tamis-LeMonda, 2011) that book exposure has a stronger impact on early rather than later oral language skills in typical children aged 4 years and over, we expected that book exposure would not predict variation in NoFR children's language skills at age 6. Due to earlier findings (Laakso et al., 2004) that FR children, as a group, require greater exposure to books to show the benefits, we hypothesized that book exposure might predict variation in FR children's vocabulary skills at age 6 years.

3. In the case of an effect of book exposure or child's interest in reading on expressive vocabulary and expressive grammar at age 6 years, would this be fully mediated by the 4;6-year language skill (expressive vocabulary and expressive grammar, respectively)? To our knowledge, this has not been studied in at-risk children earlier. We thus made no a priori hypothesis on the possible mediating effects of earlier skills.

Method

Participants

All 52 children reported here are participants in the XXX Longitudinal Study of Dyslexia. They were monolingual Norwegian, had no known neurological conditions, and had scored above 85 on a cognitive scale at age 24 months (Bayley, 2006).

The families were recruited from the arctic region of Norway via advertisements in local newspapers and brochures at local child health clinics. The families were selected in a three-stage procedure. In stage 1, parents who volunteered to participate in the study completed a short questionnaire. The questionnaire asked whether the parent had ever experienced reading and spelling problems and whether close relatives (i.e., their own parents and siblings) had experienced such problems (on a yes/no scale). In stage 2, parents were invited to a semi-structured interview. A detailed questionnaire was mailed to the parents before the interview. Parents who reported current impairments and/or a history of reading and writing impairments were asked to give a more detailed description in the interview. In stage 3, all parents were tested on a battery of literacy tests to validate their self-reported reading and spelling abilities (see XXX, 20XX, for a more detailed description of the tests and procedures employed).

Family risk (FR) group

Children were classified as being at familial risk if one of the parents met the two following criteria: (i) parent performed below -1 standard deviation on a composite score of standardized measures of reading fluency and spelling, (ii) parent self-reported a history of literacy problems. Twenty-eight children (10 girls, 18 boys) met these two criteria.

No-family risk (NoFR) group

Children whose parents performed within normal range on standardised tests of reading fluency and spelling, and had no self-reported history of reading problems, were allocated to the no-family risk group. Twenty-four children (10 girls, 14 boys) met these criteria.

Parent characteristics

Table 1 displays demographic variables and characteristics for FR and NoFR-parents at the beginning of the study. All parents were monolingual, native speakers of Norwegian. There were no significant group differences in terms of age, total household income, or performance IQ.

Measures

Home literacy environment (age 4)

The HLE was assessed via parental questionnaire when the children were 4 years old. In keeping with previous research (e.g., Puglisi et al., 2017; Sénéchal & LeFevre, 2002; Torppa et al., 2007), the questionnaire included questions about the various aspects of literacy related activities (e.g., parent-child shared reading, number of book at home, visits to library) and the children's interest in book reading. Nine items measuring informal literacy experiences were selected to construct the variable *Book exposure*, and four items assessing child's engagement with books were used to construct the variable *Interest in book reading*.

Book exposure

To create a composite score of book exposure, we used parental report of the following components of the HLE: frequency of shared reading, parent as a role model for reading, access to books, and number of books in the home. Three items assessed the frequency with which parents read to their child at bedtime and at other times, and responses to these items were rated on an 8-point scale, where 1 indicated *never* and 8 indicated *several times during the day/evening*. The role of parent as a model for reading was assessed with the item, "How often does your child see you reading to yourself?", and parents responded to it using a 7-point scale, where 1 indicated *never* and 7 indicated *very often*. Three items about how often parents (a) borrow children's books from the library, (b) buy books for their child, and (c) go to the library with the child were used to measure children's access to books, and responses to these items were given on a 7-point scale, where 1 indicated *never* and 7 indicated *very often*. Finally, parents were asked to estimate (a) the number of books on an 8-point scale from 1 (*none*) to 8 (>*121*) and (b) the number of children's books on an 8-point scale from 1 (*none*) to 8 (>*31*) they had in the home. Book exposure composite was calculated by using the mean of these nine item scores. Cronbach's alpha reliability for this composite score was .72.

Interest in book reading

Parents were asked to rate their child's interest in books and book reading by responding to four items in total. Three of these items assessed the frequency with which their child (a) browses books, (b) brings a book and looks at the pictures etc. on her/his own, (c) chooses the book that the parent will read to her/him, and responses to these items were given on a 7-point scale, where 1 indicated *never* and 7 indicated *very often*. In addition, parents were asked to report to what extent they would agree with, "My child likes to play with books.", and responses to this item were given on a 5-point scale from 1 (*strongly disagree*) to 5 (*strongly agree*). The mean of these four item scores was used to calculate the composite of interest in book reading. Cronbach's alpha reliability for this composite score was .71.

Language measures (age 4;6)

Four subtests from *The Clinical Evaluation of Language Fundementals-4 (CELF-4*; Semel, Wiig, & Secord, 2003; Norwegian adaptation by Monsrud & Rygvold, 2013) were administered to the children to measure their vocabulary and grammar knowledge at age 4;6. The *Expressive Vocabulary* subtest, labelled 'Expressive Vocabulary 4;6', was taken to evaluate the children's ability to name illustrations of people, objects, and actions (i.e., referential naming). Reliability for this subtest is α= .82 (Monsrud & Rygvold, 2013). The *Word Structure* subtest was used to evaluate the children's knowledge of grammatical rules in a sentence–completion task. Here, the child completes an orally presented sentence that pertains to an illustration, and is required to apply targeted word structure rules such as inflections and derivations. Reliability for this subtest is α= .78 (Monsrud & Rygvold, 2013). The *Formulated Sentences* subtest was used to evaluate the ability to formulate compound and complex sentences when given grammatical (semantic and syntactic) constraints. Here, the child was asked to formulate a sentence, using target words or phrases, while using an illustration as a reference. Reliability for this subtest is α= .94 (Monsrud & Rygvold, 2013). The *Recalling Sentences* subtest was used to evaluate the ability to recall and reproduce sentences of varying length and syntactic complexity. Here, the child imitates sentences presented orally by the examiner. Reliability for this subtest is α= 89 (Monsrud & Rygvold, 2013). The *Word Structure*, the *Formulated Sentences*, and the *Recalling Sentences* scores were standardized and then combined into a composite score labelled 'Expressive Grammar 4;6'. Cronbach's Alpha reliability for this composite score is .68.

Language measures (age 6)

Four subtests from *CELF-4* were used at age 6. The subtest *Expressive Vocabulary*, labelled 'Expressive Vocabulary 6', was re-administered to measure children's vocabulary skills. The subtests *Word Structure, Formulated Sentences, and Recalling Sentences*, were re-administered to assess children's expressive grammar skills. The scores from these three subtests were standardized and then combined into a composite score labelled 'Expressive Grammar 6'. Cronbach's Alpha reliability for this composite score is .81.

Research design and general procedure

The XXX project employs a repeated-measures design. That is, children in the two groups undergo the same tests and procedures over a number of occasions. All children were tested individually at ages 4;6 and 6, ± 3 weeks. Assessments were administered in a laboratory at the university and were videotaped and audio-recorded for later analyses. Each session lasted 2-3 hours and was completed with one examiner and one parent in the room (i.e., up to the age of 4;6 years).

Results

Descriptive statistics for the FR group and the NoFR group in mother's education, children's age, book exposure, interest in book reading and language skills at ages 4;6 and 6 years are presented in Table 2. The HLE data included in the analyses are based on the mothers' responses to the parental questionnaire. This is due to the lower response rate of fathers (54%) compared to mothers (89%). Distributions were inspected within the whole sample, and separately in the FR and NoFR group. All distributions were normal or close to normal and no outliers were detected. No differences were found in mother's education or children's age related to the date of mother's reports of child's book exposure and interest in book reading. Children without family risk for dyslexia outperformed children with family risk in both expressive vocabulary and expressive grammar at 4;6 and 6 years. Effect size between the two groups was large in 6-years expressive grammar and moderate in all other comparisons.

To answer the first research question, whether children with and without family risk for dyslexia differ in their book exposure or interest in book reading at age 4, two independent-samples t-tests were conducted. No differences were found between the FR and the NoFR group in children's book exposure or interest in book reading and the effect sizes between the two groups were small (see Table 2).

Next, to examine the associations between mother's educational level, parent-reported book exposure and child's interest in book reading and language outcomes, Pearson correlations were inspected separately for the FR and the NoFR groups (see Table 3 and Table 4). First, mother's education was significantly associated with book exposure, but only in the FR group. No significant associations were found in either group between mother's education and language outcomes at neither 4;6 nor 6 years of age. Second, in both groups, book exposure was significantly associated with child's interest in book reading, and these correlations were moderate to strong. Moreover, neither book exposure nor child's interest in book reading was significantly associated with expressive vocabulary or expressive grammar at 4;6 or 6 years. However, in the FR group book exposure had positive while non-significant correlation coefficients to expressive vocabulary (.27 and .38, at 4;6 and 6 years, respectively), whereas in the NoFR group the respective correlation coefficients were also non-significant, but negative (-.20 and -.28, at 4;6 and 6 years, respectively). The Difference test based on Fisher's z-transformed correlation coefficients (McNemar, 1969) confirmed that the difference between the FR and the NoFR groups in this association was close to significant at age 4;6 years ($p < .06$) and significant at age 6 years ($p < .01$).

To answer the second research question, to what extent family-risk status, book exposure and child's interest in book reading explain the variability in expressive vocabulary and expressive grammar at age 6 years, and whether FR-status serves as a moderating factor in these associations, hierarchical linear regression analyses were conducted. Expressive vocabulary and expressive grammar were used as the dependent measures, each at a time. Due to the small sample size, the effect of book exposure and child's interest in book reading were analyzed separately, resulting in altogether four separate analyses (see Table 5). Mother's education was entered into the model as the first step to covariate its effect. Family-risk status was added as the second step, and book exposure / child's interest in book reading as the third step. Finally, to test whether the effect of book exposure / child's interest in book reading was different in the FR and the NoFR groups, a group x book exposure / group x child's interest in book reading –interaction measure was added into the model as the fourth step. The model including mother's education, family-risk status, book exposure and the interaction-term group x book exposure explained 22%

of the variability in expressive vocabulary at 6 years. The effects of family-risk status and the interaction-term group x book exposure were significant, whereas the effects of mother's education and book-exposure were not. Having family-risk for dyslexia resulted in lower level of expressive vocabulary at 6 years. On the other hand, high book exposure increased the expressive vocabulary at 6 years, but only in the FR group. The effect of child's interest in book reading on expressive vocabulary at 6 years was non-significant. When predicting the variability in expressive grammar at 6 years, family-risk status was the only significant predictor explaining 19% of its variance. Having family risk resulted in lower level of expressive grammar at age 6 years.

Finally, to test whether expressive vocabulary at 4;6 years fully mediated the effect of book exposure in the FR group, an additional hierarchical regression analysis was conducted (see Table 6). The 4;6-year expressive vocabulary was entered into the model as the third step, book exposure as the fourth step and the interaction-term group x book exposure as the fifth step. The model including mother's education, family-risk status, book exposure, expressive vocabulary at 4;6 years and the interaction-term group x book exposure explained 39% of the variability in expressive vocabulary at 6 years. Family-risk status and expressive vocabulary at 4;6 years were the only significant predictors of expressive vocabulary at 6 years. The effect of the interaction-term group x book exposure was no longer significant suggesting that expressive vocabulary at 4;6 years fully mediated its effect on expressive vocabulary at 6 years.

Discussion

This longitudinal study was undertaken to investigate whether amount of book exposure and interest in reading were different in samples of Norwegian FR-children and NoFR-children. We further investigated whether these home literacy-related factors at age 4 years exerted different effects on vocabulary and grammar skills at school entry age (i.e., 6 years) depending on family-risk status, and whether they made an independent contribution to language outcomes at age 6, after controlling for the 4;6-year language skills. Our findings add to the existing literature in three ways: Firstly, we found no significant differences between FR children and their NoFR-peers in terms of book exposure and interest in reading. Secondly, our study showed that interest in book reading did not have an impact on vocabulary and grammar in either group. On the contrary, book exposure increased vocabulary skills, however only in the FR group. Thirdly, our findings showed that when early vocabulary knowledge was taken into account, the interaction effect suggesting a positive influence of book exposure on FR children's later vocabulary was no longer significant.

As expected (Gallagher et al., 2000; Lyytinen & Lyytinen, 2004; van Viersen et al., 2018), the present sample of FR children had poorer vocabulary and grammar skills at ages 4;6 and 6 years. However, the FR and NoFR children did not differ significantly in the amount of book exposure and interest in reading. While aligning well with the findings from earlier prospective studies (Elbro et al., 1998; Torppa et al., 2007; van Bergen et al., 2014), the current result contradicts the findings by Hamilton et al. (2016), who found that FR children were less exposed to books than NoFR children were. However, in Hamilton et al.'s study, there were SES-related differences between the families, which were in favour of NoFR families. We assume that the fact that FR and NoFR families in the present study were similar in their SES (as indexed by level of household income and mother's education) might explain why there were no significant difference in children's book exposure. Likewise, our result that maternal education was not correlated with child language outcomes might be affected by the SES backgrounds of the current sample. Because the majority of mothers had completed higher education (i.e., bachelor's degree) in the present study, the lack of correlation between these variables might be due to the restricted range of maternal education in our sample. However, another longitudinal study with a larger sample of Norwegian children reported also that mothers' educational level was unrelated to vocabulary skills in children at ages 5 and 6 years, irrespective of whether mothers had high or low level of education (Karlsen, Lyster, & Lervåg, 2017). As there is evidence that maternal education is a robust predictor of children's language skills (e.g., Bracken & Fischel, 2008; Hoff, 2006), more research in this field is needed to understand the mixed results concerning the role of mother's education in child language development.

In line with earlier research (e.g., Bracken & Fischel, 2008; Hume et al., 2015; Torppa et al., 2007), amount of book exposure and interest in book reading correlated significantly within both groups, indicating a positive link, regardless of whether children came from families with or without a history of dyslexia. However, the finding that children's own interest in book reading did not predict variations in vocabulary and grammar skills is different from some earlier reports (Crain-Thoreson & Dale, 1992; Deckner et al., 2006; Laakso et al., 2004). For example, Laakso et al. (2004) found that reading interest in typically developing children assessed at 14 and 24 months could predict a composite of global language at age 3;6. Similarly, Crain-Thoreson and Dale (1992) reported that reading interest at age 2 years predicted vocabulary and syntax at 2;6 years. The measure of reading interest that we used was based on parental report, whereas the measures used by Crain-Thoreson and Dale (1992), Deckner et al. (2006), and Laakso et al. (2004) were based on the observation of parent-child shared reading during the laboratory visit, and this might have contributed to the difference in the results. Another important aspect of these studies that may account for the differing results is that both interest in reading and language outcomes were measured much earlier than in the present sample. On the other hand, the insignificant effect of reading interest on subsequent language skills has been reported in several other studies, which included preschool children aged 4 years and above, (Frijters et al., 2000; Roberts et al., 2005; Sparks & Reese, 2013; Torppa et al., 2007; Weigel et al., 2006). It is noteworthy that these studies with older preschool children yielded similar results, despite that they employed different measures (e.g., Frijters et al., 2000: child's self-report; Roberts et al., 2005: a single interview question to mothers; the present study: a composite of several parent questionnaire items). Taken together, these results suggest that the extent to which children's interest in reading predicts later broader language development is age-dependent in preschool years.

The current study failed to show that exposure to books was a unique predictor of expressive vocabulary and grammar skills, which is in agreement with past research (Evans et al., 2000; Roberts et al., 2005; Sparks & Reese, 2013; Weigel et al., 2006). Although non-significant, the observed inverse correlation between book exposure and NoFR children's expressive vocabulary is worth mentioning. Earlier research with typically developing children has suggested that such negative outcomes may in part have to do with certain types of maternal behaviours during shared reading. For example, in Schmitt et al.'s (2011) study, maternal redirecting behaviours (e.g., the frequency of praise/confirmation, open-ended questions, imitative directives/modelling) were found to be significantly negatively associated with children's total expressive vocabulary. Similarly, in Sparks and Reese's (2013) study, mothers' provision of elaboration in book reading was negatively, although non-significantly, related to 4-year-olds' expressive vocabulary knowledge. It has been argued that older preschool children may indeed prefer book reading without interruptions, that is, without a parent focusing their attention by asking questions and providing explanations, and therefore, shared reading quality might deteriorate with frequency of this type of parental behaviour (Fletcher & Reese, 2005; Moll et al., 2008). The measure of book exposure in the current study was based on parental reports, and thus, it did not allow us to check this explanation. However, direct assessments in the home or lab may provide a more accurate and valid picture of parent-child interactions during book sharing and they may, in turn, contribute to a better understanding of the possible effects of these interactions on preschoolers' language skills.

Another finding from the present study was the significant interaction effect between book exposure and family-risk status. That is, variation in vocabulary skills explained by the amount of book exposure was different depending on whether the children had FR or not. A higher degree of exposure to book reading practices at age 4 appeared to generate higher scores in vocabulary at age 6 years in the FR group, whereas no such effect was found in the NoFR group. This non-existing effect could be due to several reasons. One reason could be that informal home literacy experiences measured at age 4 might lose impact on oral language skills by the end of the preschool period (age 6). In support of this assumption, empirical evidence from typically developing children suggests that the effects of parent-child shared reading are greater in younger children when vocabulary and grammar skills are in rapid progress, compared to those older than 4 years (Moll et al., 2008; Rodriguez & Tamis-LeMonda, 2011). In addition, as suggested by Evans et al. (2000), it might be that ordinary book reading activities do not significantly advance oral skills in typical children this age, over and above everyday language interactions.

The outcome observed here in the FR group contradicts the findings by Laakso et al. (2004), which showed that book reading activities predicted variation only in NoFR children's vocabulary and grammar at age 3;6. On the other hand, our finding converges with the results of a follow-up study with the same sample, which demonstrated stronger associations between shared reading and vocabulary skills in the FR group before school age (Torppa et al., 2007). Laakso and colleagues argue that children with familial risk for dyslexia may need a longer period of exposure to books to reap the benefits, and that the potential positive effects may be more evident in some language domains than others. In this light, our finding seems to provide support to this argument by showing that book exposure had a longitudinal effect on vocabulary in the FR group, while it had no effect on grammar skills. The reason for this result might have to do with the argument that grammar to a lesser extent is susceptible to environmental influences than vocabulary is (Hart et al., 2009; Hayiou-Thomas et al., 2012; Mimeau et al., 2018). It might also be that the book exposure measure we used did not capture the dimensions of the HLE, which might be predictive of growth in grammar skills (e.g., the types/genre of books used in shared reading).

Due to the longitudinal design of our study, we could also examine whether the effect of book exposure on FR children's later vocabulary skills (age 6) would be mediated by lexical knowledge at age 4;6 years (i.e., the autoregressor effect). Our findings suggest that early vocabulary skills, rather than book exposure per se, facilitate the acquisition of lexical skills obtained through informal home literacy activities. To our knowledge, this issue has not been addressed in prior studies of at-risk children. However, it may be argued that FR children with relatively better early language skills may be able to take greater advantage of home literacy activities, which in turn exerts a positive effect on their subsequent language development. In a similar way, children with stronger initial language abilities may be more likely to elicit a richer HLE, which can indirectly affect later language skills. The child's own role in reading related activities has indeed been emphasized in an earlier study of FR children, in which children who more often engaged in such activities induced their parents to read to them more frequently (Scarborough et al., 1991). Taken together, findings from the present study suggest that informal home literacy practices promoting book exposure contribute to later expressive vocabulary through their effects on early language development.

Several limitations of this study must be considered. We first note that the current sample is small. Although our findings comply with previous research, studies with larger samples are needed to replicate them. Second, it should be acknowledged that parents of our participants were primarily from middle-class, well-educated backgrounds. In addition, they had above-average mean scores on the performance IQ assessment, suggesting that the current sample of parents was not necessarily representative of the population. More research including FR and NoFR children coming from families of diverse SES backgrounds is needed to determine the extent to which our findings generalize to other SES groups. Third, the data on book exposure and child's reading interest are based on parental self-reports, which might be affected by social desirability (Debaryshe, 1995). Future research using observational measures would help confirm the current findings. Another limitation pertains to conceptualising book exposure as a measure. Our study was mainly concerned with the frequency and the amount of informal literacy practices in which children were exposed to books. Therefore, we did not measure the quality of parent-child interactions during reading activities. However, empirical evidence indicates that parents' reading style and use of dialogic techniques, such as providing definitions or asking questions about the story text, might significantly influence oral language skills (Flack et al., 2018; Mol et al., 2008). In a similar vein, certain types of books (e.g., expository books vs. storybooks) are thought to affect lexical and grammatical complexity of parental input differently, which in turn, may have an important effect on children's later language development (Noble et al., 2018). These factors need to be examined in future studies with at-risk children.

In summary, the current study contributes to our understanding of the potential role of home literacy environment on at-risk children's language skills. Our results indicate that variation in the amount of book exposure at age 4 years affects children's vocabulary skills at school entry age (i.e., 6 years) differently depending on whether they come from families with or without a history of dyslexia. High book exposure seems to increase the expressive vocabulary only in the FR group. However, this longitudinal association is completely mediated by language skills at age 4;6 years. That is, FR children with higher levels of lexical skill at earlier ages acquire more vocabulary through exposure to literacy-promoting activities at home than children with lower levels of such skill. Therefore, a stimulating home literacy environment appears to have a positive indirect effect on later language development through its effect on earlier linguistic skills. Our findings can thus be taken to suggest that early intervention (i.e., exposure to various book-reading activities) particularly for preschool FR children with poor expressive vocabulary knowledge is worth considering, and this issue should be addressed in future research.

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Table 1

Demographic Variables of the Parents at the Beginning of the Study

	No-FR parents		FR parents					Effect size
	Mean	*SD*	*Mean*	*SD*	*t*	*df*	*p*	*Cohen's d*
Total household income	2.50	1.11	2.31	1.11	0.53	45	.597	0.18
Mothers								
Age	32.74	5.38	31.07	3.77	1.06	47	.295	0.34
Performance IQ	117.58	10.75	118.82	11.05	0.05	42	.825	0.11
Fathers								
Age	34.61	5.27	35.57	6.31	-0.54	45	.591	0.17
Performance IQ	120.21	10.00	121.20	11.13	0.25	37	.622	0. 09

Note. NoFR = no family risk of dyslexia; FR = family risk of dyslexia. SD = standard deviation. Performance IQ was assessed by Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999; Ørbeck & Sundet, 2007). Household's total income in Norwegian Krone (NOK) is indexed by 1 = less than NOK 600,000; 2 = between NOK 600,000 and 700,000; 3= between NOK 700,000 and 900,000; and 4= NOK 900,000 or more.

Table 2

Ranges, Means and Standard Deviations of Mother's Education, Children's Age, Book Exposure, Interest in Book Reading, and Expressive Vocabulary and Expressive Grammar at 4;6 and 6 Years

	Range	FR n = 24-28		NoFR n = 20-24				
		M	SD	M	SD	t[a]		Effect size [b]
Mother's education	1.00 – 4.00	3.07	0.90	3.29	0.69	0.98		0.27
Child's age at mother's reports	3.54 – 4.90	4.16	0.39	4.19	0.24	0.31		0.09
Age 4 years								
Book exposure [c]	3.44 – 6.78	5.50	0.91	5.23	0.89	-0.98		0.30
Interest in book reading [c]	3.50 – 6.50	5.49	0.85	5.61	0.67	0.53		0.16
Age 4;6 years								
Expressive vocabulary	3.00 – 12.00	6.92	2.38	8.30	2.12	2.11	*	0.61
Expressive grammar [d]	-1.63 – 1.82	-0.25	0.81	0.25	0.87	2.02	*	0.60
Age 6 years								
Expressive vocabulary	3.00 – 16.00	10.62	2.84	12.23	2.19	2.33	*	0.63
Expressive grammar [d]	-2.16 – 1.48	-0.24	0.86	0.53	0.64	3.43	**	1.02

Note. FR = family risk of dyslexia; NoFR = no family risk of dyslexia. M = mean; SD = standard deviation. Educational level (1=compulsary school (year 1-10); 2=upper secondary school/high school (year 11-13); 3=bachelor's degree; 4=master's degree and/or PhD).

* $p \leq .05$, ** $p \leq .01$

[a] Degrees of freedom was 44 in group comparisons related to child's age, book exposure and interest in book reading, 45 in expressive vocabulary and expressive grammar, and 50 in mother's education.

[b] Effect sizes were estimated with Cohen's *d* (computed with pooled standard deviations).

[c] Book exposure and Interest in book reading are mean composite scores from nine and four items, respectively.

[d] Expressive grammar (4;6 years) as well as expressive grammar (6 years) are average means from three standardized test-scores.

Table 3

Pearson Correlations between Mother's Education, Book Exposure, Interest in Book Reading, and Expressive Vocabulary and Expressive Grammar at 4;6 and 6;0 Years in the FR Group

	2.	3.	4.	5.	6.	7.
1. Mother's education	.38*	.18	-.02	.15	.10	-.11
2. Book exposure, 4 years		.49*	.27	.18	.38	.05
3. Interest in book reading, 4 years			.25	-.04	-.03	-.13
4. Expressive vocabulary, 4;6 years				.68***	.51**	.56**
5. Expressive grammar, 4;6 years					.52**	.84***
6. Expressive vocabulary, 6;0 years						.50**
7. Expressive grammar, 6;0 years						

Note. FR = family risk of dyslexia.

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

Table 4

Pearson Correlations Between Mother's Education, Book Exposure, Interest in Book Reading, and Expressive Vocabulary and Expressive Grammar at 4;6 and 6;0 Years in the NoFR Group

	2.	3.	4.	5.	6.	7.
1. Mother's education	.25	.12	.15	.01	-.01	.03
2. Book exposure, 4 years		.38*	-.20	.06	-.28	.08
3. Interest in book reading, 4 years			-.04	.22	-.14	.39
4. Expressive vocabulary, 4;6 years				.38	.42*	.59**
5. Expressive grammar, 4;6 years					.01	.70***
6. Expressive vocabulary, 6;0 years						.13
7. Expressive grammar, 6;0 years						

Note. NoFR = no family risk of dyslexia.

* $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

Table 5

Summaries of the four Hierarchical Linear Regression Analyses Predicting Expressive Vocabulary and Expressive Grammar at 6 Years

	Dependent language skill at age 6 years			
	Expressive vocabulary		Expressive grammar	
Predictor	ΔR^2	β	ΔR^2	β
Step 1: Mother's education	.01	-0.03	.00	-0.08
Step 2: Family risk status	.11*	-2.22	.19**	-0.46
Step 3: Book exposure	.01	-0.23	.01	0.08
Step 4: Interaction effect Family risk status x Book exposure	.10*	1.95	.00	0.01
Total R^2 / Adjusted R^2	.22 / .14		.19 / .10	
Model fit	F(4,36)=2.59*		F(4,36)=2.16	
Step 1: Mother's education	.01	0.04	.00	-0.05
Step 2: Family risk status	.11*	-0.73	.19	1.26
Step 3: Interest in book reading	.01	-0.14	.00	0.34
Step 4: Interaction effect Family risk status x Interest in book reading	.00	0.40	.05	-1.49
Total R^2 / Adjusted R^2	.13 / .03		.24 / .15	
Model fit	F(4,36)=1.32		F(4,36)=2.83*	

Note. Standardized beta-values presented according to the final model with all independent measures included into the model.

* $p \leq .05$, ** $p \leq .01$

Table 6

Summary of the Hierarchical Linear Regression Analysis Predicting Expressive Vocabulary at 6 Years when taking into account Expressive Vocabulary at 4;6 Years

	Dependent language skill at age 6 years	
	Expressive vocabulary	
Predictor	ΔR^2	β
Step 1: Mother's education	.01	-0.08
Step 2: Family risk status	.11*	-1.49
Step 3: Vocabulary at 4;6 years	.22**	0.45
Step 4: Book exposure	.01	-0.14
Step 5: Interaction effect Family risk status x Book exposure	.04	1.34
Total R^2 / Adjusted R^2	.39 / .30	
Model fit	F(5,35)=4.45**	

Note. Standardized beta-values presented according to the final model with all independent measures included into the model.

* $p \leq .05$, ** $p \leq .01$