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by

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SETTING THE COURSE FOR ACADEMIC SUCCESS IN A MULTILINGUAL CONTEXT: EXPLORING THE ROLE OF EARLY CHILDHOOD EDUCATION AND CARE (ECEC) IN LUXEMBOURG

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Affidavit / Statement of originality

I declare that this thesis:

- is the result of my own work. Any contribution from any other party, and any use of generative artificial intelligence technologies have been duly cited and acknowledged;
- is not substantially the same as any other that I have submitted, and;
- is not being concurrently submitted for a degree, diploma or other qualification at the University of Luxembourg or any other University or similar institution except as specified in the text.

With my approval I furthermore confirm the following:

- I have adhered to the rules set out in the University of Luxembourg's Code of Conduct and the Doctoral Education Agreement (DEA)[1], in particular with regard to Research Integrity.
- I have documented all methods, data, and processes truthfully and fully.
- I have mentioned all the significant contributors to the work.
- I am aware that the work may be screened electronically for originality.

I acknowledge that if any issues are raised regarding good research practices based on the review of the thesis, the examination may be postponed pending the outcome of any investigation of such issues. If a degree was conferred, any such subsequently discovered issues may result in the cancellation of the degree.

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“Education is our passport to the future,

for tomorrow belongs to the people who prepare for it today."

Malcom X

Summary

Early childhood education and care (ECEC) has been widely recognized as a promising approach to alleviating educational disparities between children of different backgrounds. By providing disadvantaged children with access to a supportive and stimulating environment during their formative years, independent of their home circumstances, ECEC may foster a more equal playing field in regard to academic achievement. In light of Luxembourg's persistent educational disparities and highly funded yet fragmented and partly privatized ECEC system, this thesis investigated the potential of ECEC attendance in Luxembourg in narrowing achievement gaps between children of different family backgrounds.

For this, the present thesis explored five research interests across four studies, namely 1) ECEC attendance, 2) the association between ECEC attendance and short-term academic achievement, 3) the association between ECEC attendance and long-term academic achievement, 4) the association of home environment influences, i.e., exposure to the language of instruction and media, with academic achievement, and 5) differences in these relationships based on family background characteristics. For this, secondary analysis of full-population data from the Luxembourg School Monitoring Programme, including retrospective ECEC information, was conducted.

Multivariate analyses within *Study 1* found attendance of ECEC to be generally high across different types of ECEC, with moderate to high dosage of childcare attendance in line with the affordability of ECEC in Luxembourg. Complex interactions of attendance, dosage, and family background were found, with indications of light attendance disparities based on migration background and home language. Study 1 also indicated that associations between ECEC and academic achievement were stronger for both types of preschool than for childcare, and stronger for Luxembourgish listening comprehension than for early literacy and mathematics, showing the importance of ECEC in regard to language acquisition. In general,

associations between ECEC attendance and achievement were positive, but small. Findings on moderation patterns across family background appeared less consistent due to a high number of subgroups.

Based on these inconsistent moderation patterns in Study 1, *Study 2* focused on the short-term association between childcare attendance and Luxembourgish listening comprehension, depending on children's use of the languages of instruction, Luxembourgish and/or German, at home. The multilevel analysis underlined that only within the disadvantaged home language group, attendance and a longer duration of childcare were beneficial for Luxembourgish listening comprehension in first grade. Extending findings on the directionality of ECEC dosage, childcare duration was found to be in a nonlinear relationship with Luxembourgish listening comprehension, indicating that after some initial gains with a longer duration, a fourth year was not associated with greater outcomes.

Beyond the short-term associations investigated in Studies 1 and 2, *Study 3* aimed to shed light on the long-term associations between childcare attendance and academic achievement in the Luxembourgish education system, in particular, mathematics, reading comprehension, and grade retention between Grades 1 and 5. A main focus of this study was to test whether socioeconomic status (SES) and home language moderated the relationships. Results indicated limited long-term advantages of childcare attendance across the whole sample, more pronounced benefits in some outcomes for children who do not speak Luxembourgish or German at home, and fewer benefits in some outcomes for those from lower-SES backgrounds. Thus, the commonly observed pattern that disadvantaged students benefit more from early interventions was only corroborated for one dimension of disadvantage. In particular, grade retention rates were significantly impacted, with disparities between home language groups being nearly alleviated by childcare attendance, suggesting potential foot-in-the-door processes of childcare. Again, a nonlinear relationship for childcare

duration indicated that a fourth year of attendance was not associated with further benefits, which underlines the importance of the extent and content of ECEC.

Lastly, *Study 4* investigated both the influences of ECEC and aspects of the home environment on Luxembourgish listening comprehension and early literacy in Grade 1, differentiating between three home language groups based on language of instruction use at home. In regard to ECEC, preschool attendance was positively associated with Luxembourgish listening comprehension and early literacy only among children who do not speak Luxembourgish or German at home, further underlining the moderation pattern frequently observed throughout this thesis. The study, however, also emphasized the importance of the home environment: Exposure to the language of instruction in more contexts at home and exposure to books were independently associated with higher Luxembourgish listening comprehension and early literacy, while exposure to other forms of media, video and audio, were unrelated or even negatively related to language and literacy.

Taken together, the findings presented in this thesis constitute the first large-scale investigation into the relationship between ECEC attendance and academic achievement within the diverse student population in Luxembourg. The thesis highlights the positive role of ECEC in reducing educational disparities between children from different home language backgrounds. However, findings of this thesis also point to its still unrealized potential, as evidenced by relatively small effect sizes and indications of access inequalities. In conclusion, this thesis advocates for a greater focus on assessing and improving ECEC quality in Luxembourg in both research and policy, to set all children, regardless of their family background, (early) on a successful course in the multilingual school context.

Acknowledgments

Although I have postponed writing these acknowledgments as long as possible, I am truly glad I get the opportunity to pause and properly reflect on those last four years—a privilege not every job offers. Because of this, I get to express my gratitude to all the people that helped shape me into the researcher I am today and made those four years a wonderful time to remember.

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Lastly, I'd like to thank my family, for always being the solid rock beneath my feet, for supporting me throughout my studies and now my PhD, and for being the home I always love to go back to. Thank you very much.

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Author Transparency Statement

The present thesis is based on three papers published or (to be) submitted in peer-reviewed journals and one published chapter in the *Bildungsbericht Luxembourg 2024*, here included as Study 1. Study 1 is largely based on a comprehensive policy report (Hornung et al., 2023), for which I was one of the main authors. As the policy report is substantially longer and not peer-reviewed, Study 1 represents a condensed and adapted version of the policy report, tailored for a broader national audience. Where relevant, the thesis cites the policy report to acknowledge its role in the analyses and findings presented here.

Lena Maria Kaufmann

Belval, 28.11.2025

Declaration of Generative AI and AI-Assisted Technologies Use

During the preparation of this thesis, the author utilized the following AI-based tools: Grammarly (version 1.104.1, https://www.grammarly.com), DeepL Write Pro (version 25.1.11615133), Open AI's ChatGPT-4o (2024), and Microsoft's Copilot (version GPT-4-turbo) (2025) were used for proofreading purposes to improve clarity, linguistic accuracy, and readability. All AI-generated suggestions were reviewed and edited by the author who takes full responsibility for the final wording.

Perplexity AI (2025) and Microsoft's Copilot (2025) were used as a search engine for coding and statistics queries. All suggestions were reviewed and, where appropriate, cross-referenced before being integrated. Additionally, Microsoft's Copilot (2025) assisted in sorting papers thematically for the different subchapters. All cited information was checked and validated by the author who takes full responsibility for the contents presented in this thesis.

Lena Maria Kaufmann

Belval, 28.11.2025

Declaration of Authorship

I hereby declare that the present dissertation is my own work and that, to the best of my knowledge and belief, it contains no materials previously published or written by another person except where due acknowledgment has been made in the text.

Lena Maria Kaufmann

Belval, 28.11.2025

1 General Introduction

Luxembourg faces difficulties in enabling all children, regardless of their family background, to achieve equal success at school (see OECD, 2019). Educational inequalities in the country appear to be partly rooted in the heterogeneity of Luxembourg's student population, which is characterized by a high rate of immigration and high linguistic diversity (MENJE & SCRIPT, 2024). The combination of an increasing number of students with non-instructional home languages (SCRIPT, 2020) with Luxembourg's demanding multilingual curriculum, which expects students to be competent speakers in Luxembourgish, German, and French by the end of schooling (Sattler, 2022), has long been acknowledged as a factor in the educational difficulties that many children face (Hornung et al., 2021; Maurer-Hetto et al., 1991; Sonnleitner et al., 2021).

To respond to these challenges, it is prudent to focus on the start of children's development. In the first years of life, children learn rapidly and are highly susceptible to both positive and negative experiences and environments (National Research Council, 2000). As described in the "Heckman curve" (Heckman, 2006), economic investments in children are predicted to be more effective when they are young (Rosholm et al., 2021). As children "who fall behind may never catch up" (Heckman, 2006, p. 1900), early childhood education and care (ECEC) can play an important role in reducing academic inequalities due to its well-documented impact on academic success and other developmental outcomes (Bennett, 2012; Council of the European Union, 2019; Melhuish et al., 2015).

ECEC in Luxembourg has already been recognized as essential for supporting early development, as attendance has been obligatory for all 4- and 5-year-olds since 1992 (Hekel & Simoes Lourêiro, 2021). The ECEC landscape in Luxembourg is further characterized by one of the highest attendance rates in countries in the Organisation for Economic Co-operation and Development (OECD) in the age range under 3 (OECD, 2022b), a unique multilingual ECEC

provision (Service National de la Jeunesse, 2018), and a heterogeneous mix of various systems and service providers (Honig & Haag, 2011). While the need for a systematic evaluation of ECEC in Luxembourg has been recognized (OECD, 2022b), no large-scale quantitative investigation of the relationship between ECEC attendance and academic achievement in the country has been undertaken prior to this PhD project.

The present thesis thus aimed to investigate the following research interests: Research Interest 1 (RI 1) explores ECEC attendance and dosage in Luxembourg. Research Interest 2 (RI 2) examines the short-term relationship between ECEC and academic outcomes in first grade, in particular, listening comprehension, early literacy, and mathematics. Research Interest 3 (RI 3) investigates possible fade-out effects in the long-term relationship between ECEC attendance with reading comprehension, mathematics, and grade retention, assessed in later grade levels.

Beyond ECEC, family as the primary learning context should not be overlooked (Byrnes & Miller, 2007), as early home learning experiences can significantly support—or hinder—children's language and literacy development (M. A. Foster et al., 2005; Lehrl, Evangelou, et al., 2020), and act as a key mechanism behind educational disparities (Linberg, Attig, et al., 2020). Thus, for Research Interest 4 (RI 4), the aim was to investigate the relationship of selected aspects of the home language and literacy environment (i.e., exposure to the language of instruction and different types of media) with early academic achievement, in particular with precursors to literacy acquisition.

In light of Luxembourg's distinct achievement gaps between students of different SES and home language backgrounds, a main focus of this thesis rests on whether—and how—ECEC and aspects of the home environment may reduce these disparities. Thus, a central research aim across all these strands is to examine how these relationships vary depending on students' socioeconomic status (SES) and home language (RI 5).

To achieve these aims, the next chapter of this paper-based dissertation outlines academic achievement in a narrative literature review, split into the four outcome domains of interest: language, literacy, mathematics, and grade retention. A subchapter illustrates how academic achievement differs based on family background and which role home environment plays in this association. The third chapter introduces ECEC generally, describes the Luxembourgish ECEC system, and reviews literature on ECEC attendance. Several subchapters delve into the literature on the association of ECEC with academic achievement and factors that moderate this relationship. The fourth chapter of the present thesis details the concrete research interests that underlie this thesis and the contributions that each study makes towards those interests. The chapter also specifies the statistical methods used for each research question, from linear and logistic regressions to structural equation modeling, illustrating the variety in statistical approaches in response to the complexity in ECEC research. After the presentation of the four included published or submitted studies in this thesis, the ninth chapter will summarize and discuss the studies' findings in regard to each research interest as well as present implications, limitations, and suggestions for further research. Lastly, chapter ten concludes the thesis by shortly highlighting the main findings and implications for future ECEC research in Luxembourg and beyond.

2 Academic Achievement

Academic achievement has far-reaching consequences for a person's prospects for further education, professional trajectories, and prosperity (Chiswick et al., 2003; Ritchie & Bates, 2013). The term encompasses performance in various domains and subjects that often build upon each other. The relevance and development of four such domains, oral language skills, literacy skills, mathematics and educational trajectories, which are key for this thesis, is described in more detail.

2.1 Oral Language Skills

The process of language acquisition is impacted by both genetic dispositions and environmental influences (Hoff, 2006b). In particular, the quantity but also quality of child-directed speech, indicated, for example, by lexical complexity and reciprocity, are well-known predictors of the speed in which children develop their language skills (see Golinkoff et al., 2019; Hoff, 2006b).

Language skills can be categorized into various subskills that are typically classified as either expressive or receptive (Benedict, 1979). In early childhood, commonly assessed domains include vocabulary, grammar, and listening comprehension.

Listening comprehension is a multifaceted construct and a foundational prerequisite for reading comprehension (Hogan et al., 2014). It involves a range of cognitive and linguistic processes, drawing on core skills such as vocabulary, grammar, inferencing, and background knowledge (Babayiğit & Shapiro, 2020; Hogan et al., 2014). Importantly, listening comprehension serves as an independent predictor of reading comprehension, beyond other reading precursors (Hogan et al., 2014; Kendeou et al., 2009), and predicts the rate at which reading comprehension skills develop over time (Lervåg et al., 2018).

Especially the proficiency in the *language of instruction* is essential for children's future academic success (Einarsdóttir et al., 2016; Golinkoff et al., 2019; Schleppegrell, 2001). It

influences not only the acquisition of literacy but also how well instruction in other subjects can be understood, as seen in the mathematics and science performances of multilingual learners (Giguere et al., 2024; Greisen et al., 2021; Van Laere et al., 2014).

2.2 Literacy Skills

Literacy skills relate to written language and include proficiency in e.g., decoding, spelling, reading comprehension, and text production. In the current society in which reading and writing are integral to everyday life, literacy skills are considered one of the essential outcomes of formal education and predict academic success and labour market outcomes (Hernandez, 2012; Shomos & Forbes, 2014; UNESCO, 2005).

Early literacy skills begin developing in preschool (Juska-Bacher, 2013) and are precursors for literacy development. They encompass, for example, word decoding, phonological awareness and memory, alphabet knowledge, and rapid automatized naming of letters and digits (Hornung et al., 2017b; Landerl et al., 2022; Leppänen et al., 2008; Lonigan & Shanahan, 2009). Word decoding skills play an especially important role: Together with listening comprehension and vocabulary, they account for nearly all the variance in early reading comprehension (Lervåg et al., 2018) and continue to additionally predict reading outcomes as far as third grade (de Jong & van der Leij, 2002).

In multilingual learners, code-related (i.e., phonological awareness) and oral-language related precursors (i.e., vocabulary and listening comprehension) have been found to predict later literacy, both within the same language and across languages (see meta-analysis by Bhalloo & Molnar, 2023; Giguere et al., 2024).

2.3 Mathematics

Besides language and literacy skills, developing proficiency in mathematics is also a main goal of education, as it can have long-lasting benefits for a person's academic and

professional career: Proficiency in mathematics is one of the strongest predictors of later educational and academic success (Duncan et al., 2007; Jordan et al., 2009), and is thus connected to greater opportunities in the labour market (Chiswick et al., 2003) and attaining a higher SES (Ritchie & Bates, 2013).

Research on early precursors to mathematical proficiency is often focused on the content area "quantities, numbers and operations" (Deutscher & Selter, 2013) in the form of early number competence (Georges et al., 2023; Hornung et al., 2014). The latter encompasses the ability to compare magnitudes, the knowledge of Arabic numerals and other subskills (Mix, 2023) that have been found to predict long-term mathematical development (Watts et al., 2014). However, often-assessed spatial skills like mental rotation, spatial visualization, or spatial perception have also been shown to play an important role for later mathematical outcomes (Georges et al., 2019; Linn, 1985; Young et al., 2018).

Next to number-specific abilities, domain-general cognitive abilities such as receptive vocabulary also play a role in the development of mathematical skills (Hornung et al., 2014; Passolunghi & Lanfranchi, 2012). This underlines that numerical processing is not independent of linguistic processing (Dowker & Nuerk, 2016), as language is both the medium to "communicate, represent and retrieve mathematical knowledge" (Peng et al., 2020, p. 595), but also the medium to support memory processes and mathematical reasoning during learning (Peng et al., 2020). This connection between language and mathematics is also illustrated by well-documented differences in mathematical performance based on language skills for both native speakers and second-language learners (Greisen et al., 2021; Peng et al., 2020; Schiltz et al., 2024).

2.4 Educational Trajectories

Beyond performance in core subjects such as language, literacy, and mathematics, academic success is indicated by a student's educational trajectory. Common indicators include

graduation rates, early school leaving, school track decisions, and grade retention (Musso et al., 2020). Given that grade retention is one of the outcomes examined in this thesis, it is described in more detail in the following.

Grade retention refers to the educational measure of keeping students at the same grade level for an additional year if they did not achieve the minimum learning goals of the school grade. Countries that adopt grade retention aim to give students more time and a second chance to achieve the learning goals and keep the classroom performance of a grade level homogenous (OECD, 2020a). However, the effectiveness of grade retention remains contested. Research has shown either negligible effects on various academic and socio-emotional outcomes (Goos et al., 2021; Ottenbacher et al., 2024; Wills, 2023) or even adverse consequences, such as increased dropout rates (Bowman, 2005; Goos et al., 2021; Jimerson, 2001; Tingle et al., 2012).

2.5 Disparities Based on Family Background

In numerous countries, students' academic achievement has been shown to vary depending on their family background, including factors such as SES, migration background, and the language spoken at home (Hattie, 2010; Heath, 1983).

The link between SES and academic achievement has been extensively studied for decades, highlighting mostly stable to increasing disparities in educational outcomes as well as stronger SES disparities in high-income countries (Broer et al., 2019; Chmielewski, 2019; S. W. Kim et al., 2019; Sandsør et al., 2021; Sirin, 2005). Generally, meta-analytic results suggest associations of a small to medium effect size between SES and academic achievement (Korous et al., 2022; Letourneau et al., 2011). However, some evidence indicates that the achievement gap might widen as children grow older (Feinstein, 2000). SES-related disparities have been observed across various domains and indicators of academic achievement. For instance, SES has been linked to early language outcomes, including vocabulary (Hart & Risley, 1995), language delays (Ribeiro et al., 2022), and literacy development (Hemmerechts et al., 2017).

These differences are also reflected in standardized assessments, where SES accounts for between 4% and 19% of the variance in scores measured by the Programme for International Student Assessment (PISA), depending on the education system (Klieme et al., 2010). Furthermore, SES has also been shown to impact early mathematical development (Jordan et al., 2009; Starkey et al., 2004), which continued to affect mathematics achievement in later years (Jordan et al., 2009). Associations between SES and academic achievement can also be seen in grade retention (Klapproth & Schaltz, 2015; OECD, 2020a), dropout rates (Sznitman et al., 2017), and participation in higher education (Nikula, 2018).

Academic performance varies not only by SES but also by migration background. PISA data show that in many countries, including France and Germany, students with a first- or second-generation migration background tend to perform worse in both reading comprehension and mathematics compared to their native peers (Stanat & Christensen, 2006; Weis et al., 2019). Interestingly, disparities in mathematics and science achievement based on migration background observed in the 2018 German PISA data were no longer statistically significant once SES, parental education, and the language spoken at home were accounted for (Weis et al., 2019). This indicates that achievement gaps based on migration background are intertwined with disparities related to language background.

Several studies have documented educational disadvantages for students whose home language differs from the language of instruction. For instance, multilingual children frequently exhibit lower vocabulary skills in the language of instruction during early childhood compared to their monolingual peers (for a review, see Hammer et al., 2014). The review also revealed that multilingual children tend to perform lower in early literacy assessments but may catch up over time (Hammer et al., 2014). Additionally, a large-scale study in South Africa—a country with 11 official languages—found that students were disadvantaged in their language learning and literacy when the language of instruction did not match their home language (Van Staden

et al., 2016). A similar trend could be found in mathematics, where learners of the language of instruction underperformed in comparison to their peers, as found by a review (Schiltz et al., 2024). These differences in mathematics performance based on home language can be partially attributed to reading comprehension in the language of instruction. This was demonstrated by studies from Germany (Paetsch et al., 2016) and Luxembourg (Greisen et al., 2021), where the disadvantage in mathematics among students with home languages distant from German disappeared once reading comprehension was controlled for.

In addition, differences based on immigration and language background are also evident in other educational indicators, such as grade retention, early school leaving, and school track placements (Backes & Hadjar, 2024; Bonvin et al., 2008; Weis et al., 2019).

2.5.1 Home Environment Impacts as a Mechanism Behind the Disparities

Why and how these disparities in academic achievement are reproduced is discussed in Bourdieu's theory of cultural capital (Bourdieu & Passeron, 2000). According to Bordieu, parents with higher social status possess and are able to invest greater amounts of economic, cultural and social capital to support the education of their children. Thus, these parents do not only have more resources, such as familiarity with the education system, information about career paths, and the financial means to afford tutoring or private schooling; they are also assumed to place a higher value on education and take risks in educational decision-making where the payoff may lie further in the future (Boudon, 1974; Bourdieu et al., 1981; Ditton, 2011). Beyond these "secondary effects" that influence educational pathways through family decisions, children from advantaged SES backgrounds often benefit from “primary effects” within the home environment. These include a richer language environment, more frequent engagement in cognitively stimulating activities, and overall higher quality of learning interactions at home (Boudon, 1974; Linberg, Attig, et al., 2020). Together, these mechanisms contribute to the reproduction of educational inequalities across generations.

Fittingly, the home learning environment (HLE) has garnered attention in educational research since the 1990s (Lehrl, Evangelou, et al., 2020). While definitions of this multifaceted construct vary between studies, a model by Kluczniok et al. (2013) proposes three components of HLE that are directly or indirectly linked to children's development.

The first component, structural aspects, includes material resources such as access to books as well as family characteristics, such as household income, parental education and migration background. The second component, parents' educational beliefs, encompasses values, perceptions, expectations, and aspirations regarding their children's education. These two dimensions—structural aspects and educational beliefs—shape the frequency and quality of the third dimension, namely educational processes (Wolf et al., 2025). Educational processes refer to the interactions between parents and children, such as stimulating conversations and emotional support as well as home activities, such as board games, media use, or shared book reading. These processes are postulated to have a direct impact on children's academic achievement (Kluczniok et al., 2013; Wolf et al., 2025). Empirical evidence supports this, showing that both quality and quantity of learning activities are associated with academic achievement (Linberg, Lehrl, et al., 2020).

Several studies have indicated that HLE may mediate the relationship between SES and academic achievement, especially in regard to early literacy development and achievement in early grades (M. A. Foster et al., 2005; Jiang et al., 2024; Y. Li et al., 2025), underlining that "what you do with your child is more important than who you are" (Lehrl, Evangelou, et al., 2020, p. 2). The HLE may thus serve as a protective factor, which is stressed by Esmaeeli et al. (2024) in relation to reading difficulties.

The HLE in early childhood seems to play a particularly important role in shaping children's academic trajectories. In a German study by Anders et al. (2012), early numeracy skills at age three were already impacted by the quality of the HLE. Additionally, the effects

of HLE may extend well beyond the preschool years. Longitudinal research has demonstrated associations between early HLE and academic achievement in third grade (Melhuish et al., 2008) and secondary school (Lehrl, Ebert, et al., 2020; Tamis-LeMonda et al., 2019; Toth et al., 2020). These long-term associations persist even when controlling for academic precursors, prior achievement, and family background characteristics (Niklas & Schneider, 2017).

While much of the research on HLE has focused on its association with SES, differences in HLE have also been observed in relation to migration and language background (Rivera et al., 2024). A meta-analysis by Dong and Chow (2022), for example, indicated that associations between HLE factors (such as shared reading practices) and bilingual children's second language acquisition in English were only moderate and thus smaller than those generally found for first language learning. They suggest that other factors, such as school variables, might be more important for second language learning.

Notably, Relyea et al. (2020) expanded on the HLE construct to specify a Home Language and Literacy Environment (HLLE) that includes both home language use and home literacy environment as distinct, but related sub-aspects of the home environment. This underscores the importance of both of these aspects, especially when examining the home environment of multilingual children.

2.6 Academic Achievement and Educational Disparities in Luxembourg

According to large-scale monitoring results from PISA 2018, Luxembourg’s tracked school system performed below the OECD average in reading comprehension, mathematics, and science (SCRIPT, 2020). However, the country’s highest-achieving students performed on par with the OECD average, while students in the middle and lower performance ranges scored significantly lower. This indicates a wider variance of performance in Luxembourg compared to other OECD countries (SCRIPT, 2020).

This disparity in student performance is partly attributed to differences by SES, migration, and language background factors. In reading comprehension, the gap between socioeconomically advantaged and disadvantaged students exceeded 120 points—making it the largest SES-related achievement gap among all OECD countries (Weis et al., 2019). Similar gaps were also evident in mathematics and science (SCRIPT, 2020).

Luxembourg has one of the highest student migration rates among OECD countries (United Nations, 2020), illustrated by the fact that 44% of elementary school students do not have the Luxembourgish nationality (MENJE & SCRIPT, 2024). However, the achievement gap in reading comprehension between first-generation migrant students and their native peers was only 35 points, aligning with the OECD average. Comparable gaps were also observed in mathematics and science (SCRIPT, 2020).

Reflecting the country's linguistic diversity, students report a wide range of home languages, including Portuguese, English, and various Slavic languages, in addition to the three national languages used as instructional languages in school[1]. By 2024, fewer than one-third of students identified Luxembourgish as their first home language (MENJE & SCRIPT, 2024). Students who took part in PISA in a test language that differed from their home language[2] (which constituted 45% of the Luxembourgish sample) scored on average 68 points lower in reading comprehension than their peers who spoke the test language (German, French, or English) at home. This gap presents a meaningful difference on the PISA scale, which is normed at a mean of 500 and a standard deviation (*SD*) of 100, and exceeded the average OECD language gap (SCRIPT, 2020). While differences related to migration and language

[1] A unique characteristic of the Luxembourgish educational system is its highly multilingual nature, as the three national languages are introduced progressively as languages of instruction within the public school system. Luxembourgish—alongside French since 2017—is spoken and promoted in ECEC (Service National de la Jeunesse, 2018). Beginning in first grade, German becomes the primary language for formal schooling and literacy development. French is taught orally as a second language at this stage and gradually takes on a more prominent role as a medium of instruction in later school years.

[2] Because of the linguistic similarities between languages, students who speak Luxembourgish at home and answer the test in German were counted towards same language test takers.

background were reduced when controlling for SES, they remained statistically significant (SCRIPT, 2020).

National monitoring data in Luxembourg corroborate these findings, revealing that gaps in early literacy skills between language groups are already evident in first grade and tend to widen in subsequent years (Hornung et al., 2021; Sonnleitner et al., 2021). A similar trend was observed in mathematics from first to third grade, likely influenced by the shift in language of instruction from Luxembourgish to German, which poses challenges for the reading comprehension of many students (Hornung et al., 2021).

These disparities are mirrored in students' educational trajectories. Luxembourg's grade retention rate, which stands above the OECD average (3.6% compared to 1.5% in primary and 9.7% compared to 2.2% in lower secondary education; OECD, 2024), varies significantly by SES and nationality. Disadvantaged students with low SES or non-Luxembourgish nationality tend to be retained at much higher rates than their advantaged peers, both in primary and secondary school (Backes & Hadjar, 2024). School track decisions and early school leaving also vary by background: while 70% of socioeconomically advantaged students are placed in the highest academic track in secondary education, this is only the case for 14.2% of socioeconomically disadvantaged students. Moreover, more than half of early school leavers do not hold the Luxembourgish nationality (Backes & Hadjar, 2024).

Taken together, these findings highlight the need to explore effective strategies for reducing the significant disparities in educational outcomes in Luxembourg.

3 Early Childhood Education and Care

3.1 Definition, Historical Context, and System Classifications

Early Childhood Education and Care, abbreviated as ECEC, is an umbrella term for "any regulated arrangement that provides education and care to children from birth to compulsory elementary school age" (European Commission, 2022). In 2017, the EU recognized access to affordable and good quality ECEC as a right of all children (Council of the European Union, 2019).

Historically, out-of-family care was introduced as a protective measure to ensure the safety and well-being of children at risk of neglect, particularly in situations where both parents were compelled to work due to existential economic pressures. It was only later that a pedagogical focus was added to the aims of ECEC services, shifting their focus from primarily supporting economically disadvantaged populations to serving all children (Wiesner et al., 2013).

Such universal ECEC programs are today still predominantly found in European countries, with integrated systems across ages that combine care and education especially common in Scandinavian nations (Lazzari & Vandenbroeck, 2012). In contrast, ECEC provision in the United States is more fragmented, varying significantly across states (CCAoA, 2025; Kamerman & Gatenio-Gabel, 2007). Despite this fragmentation, U.S.-based research on several well-designed and targeted ECEC programs for disadvantaged children from low-income families, such as Head Start and the Perry Preschool Project, has demonstrated substantial cost-benefits of ECEC (Barnett & Nores, 2015) and sparked global interest in early childhood education from an economic perspective (Spieß, 2013).

Given the diversity of ECEC systems across countries and the unique services each country offers for different age groups, ECEC encompasses a wide range of care types delivered through various providers and institutions. To facilitate the comparison of ECEC

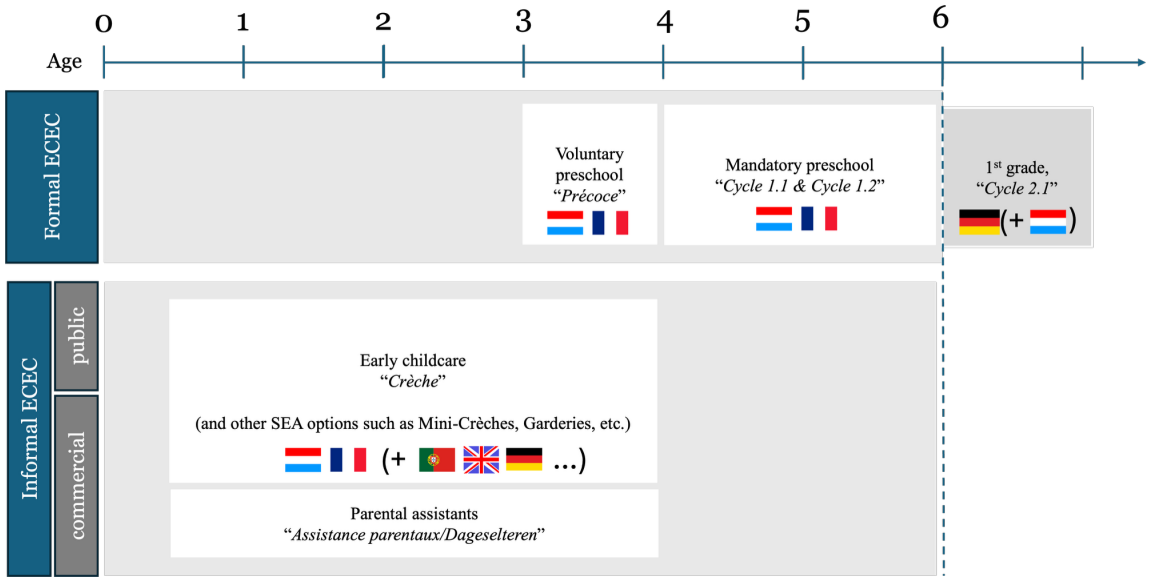
systems across countries, the International Standard Classification of Education (ISCED), developed by the United Nations Educational, Scientific and Cultural Organization (UNESCO), helps categorize ECEC programmes into two broad categories: "early childhood educational development programmes [which] are targeted at children aged 0 to 2 years; and preprimary education programmes [which] are targeted at children aged 3 years until the age to start" primary school (OECD et al., 2015, p. 20). The ISCED-0 category of ECEC is thus split in ISCED-01 for younger and ISCED-02 for older children since 2011.

3.1.1 The ECEC System in Luxembourg

The multilingual context of Luxembourg features a universal, financially subsidized, but fragmented ECEC system (Bollig et al., 2016; Honig, 2015; OECD, 2022b). It has also been named a “double split system” (Bollig et al., 2016, p. 78), referring to the coexistence of both formal and non-formal, as well as public and private services. This results in a significant heterogeneity in both types of service and quality of provision (OECD, 2022b).

At the ISCED-01 level, children may attend early childcare centers (*crèches*) or be in the care of childminders (*Dageselteren*) from birth until the age of four. These types of ECEC are classified as non-formal. At the ISCED-02 level, the public school systems offer one year of early voluntary preschool for children aged three to four (*précoce*), followed by two mandatory preschool years for children aged four to six (*Cycle 1.1* and *Cycle 1.2*). These two types of preschool services are considered formal ECEC (see Figure 1).

Figure 1. *Overview of the doubly split ECEC system in Luxembourg*



Note. Partially adapted from Honig & Haag (2011). ECEC = everything before the dotted line.

Early Childcare

As legal entitlement to ECEC begins at birth, children between the ages of 0 and 4 may attend childcare centers which are subsidized by a voucher system known as the *Chèque service acceuil*. These vouchers guarantee each child 20 free hours of childcare per week for 46 weeks per year. Additional hours are subsidized based on factors such as parental income and number of siblings (F. Berger et al., 2023). On average, public subsidies for childcare in Luxembourg amount to nearly €10,000 per child in care annually (Meisch, 2025b).

Due to high demand, public ECEC services in Luxembourg are unable to meet the needs of all families, leading to a substantial reliance on the private childcare sector. This sector includes both non-profit providers and commercial providers (Wiltzius & Honig, 2015). Public childcare providers represent a relatively small share of the overall landscape—approximately 24% in 2025 (Meisch, 2025b) after the number of private-commercial childcare places has been clearly increasing over the previous years (MENJE, 2024). As a result, much of the

responsibility for early childcare provision lies within the free market, placing the burden of choice on parents.

Between 2016 and 2018, new regulations were introduced for non-formal childcare, including the multilingual education programme *éducation plurilingue* (MENJE, 2016; Service National de la Jeunesse, 2018). Under this initiative, childcare centers must promote Luxembourgish and French in order to qualify for the voucher scheme. The curriculum and pedagogical orientation of non-formal ECEC, implemented in 2017, is outlined in the *Rahmenplan für non-formale Bildung* (MENJE et al., 2021). It underlines seven fields of action in ECEC: emotions and social bonds; values and participation; language, communication, and media; art, creativity, and aesthetics; movement and health; science and technology; and lastly transitions in early childhood. Staff working in childcare are required to hold either a vocational qualification, a diploma in education, art, music, language, or motor skills, or to have completed a basic training aimed at developing pedagogical competencies (Meisch, 2025a). Furthermore, employees in early childcare must be proficient in at least one or two[3] of Luxembourg's three official languages: Luxembourgish, German, and French.

The quality assurance systems checking adherence to these regulations are still subject to the ongoing reform (OECD, 2022b). Following a transition period that ended in 2019 and a pause in implementation due to the COVID-19 pandemic, renewed efforts to monitor adherence to baseline quality guidelines resumed in 2023 with increased control visits by regional officers (Meisch & Hahn, 2025).

Generally, childcare centers have some flexibility in the languages they offer. As a result, the linguistic landscape in ECEC settings extends beyond the country's three official languages—Luxembourgish, French, and German—to include other widely spoken languages

[3] In the publicly funded ECEC sector, language proficiency in Luxembourgish and French has been required since the implementation of the éducation plurilingue in 2017. In the commercial ECEC sector, proficiency in one official language is sufficient (De Moll et al., 2024).

such as Portuguese or English. This multilingual environment means that multiple languages are often spoken within a single childcare setting, reflecting the linguistic diversity that characterizes Luxembourg's ECEC system (MENJE, 2016).

Preschool

Before entering formal schooling in Grade 1 (or *Cycle 2.1*) at age six, all children attend two years of mandatory preschool, referred to as *Cycle 1*[4]. Prior to this, they may attend the voluntary preschool year known as *précoce*, which is also offered free of charge. In some cases, attendance in *précoce* occurs alongside non-formal ECEC attendance (Bollig et al., 2016).

In terms of staffing, mandatory preschool is led by teachers holding a bachelor's degree in educational sciences. In the voluntary preschool year, one such teacher typically works in tandem with a caregiver who has completed a vocational training (Meisch, 2025a). The pedagogical framework for both voluntary and mandatory preschool is outlined in the *Plan d'études école fondamental* (MENFP, 2011) and the *Plan cadre pour l'éducation précoce* (MENJE, 2018). The preschool curriculum aims to foster school readiness by promoting oral language skills in Luxembourgish, early mathematical reasoning, environmental exploration, psychomotor development, creative expression, and social-emotional skills and values (MENJE, 2018).

Informal care at home

As an alternative to formal and non-formal ECEC, parents in Luxembourg may opt for informal care by family members. In support of this choice, the country offers a flexible parental leave policy. In addition to 20 weeks of paid and mandatory maternity leave—12 of which must be taken after childbirth—both parents are entitled to non-transferable, paid

[4] The first year is called Cycle 1.1, the second Cycle 1.2.

parental leave. The duration of this leave ranges from 4 to 20 months, depending on employment hours and the selected leave model (e.g., 4 to 6 months of full-time leave) (F. Berger et al., 2023).

3.2 Attendance in ECEC

Generally, attendance in ISCED-01 is lower than attendance in ISCED-02. Statistics of the European Union indicate that in EU countries overall, 60% of children under three did not attend ECEC in 2024, while only 10% of children between age three and the primary school age did not attend ISCED-02. Stark differences appear between countries: In Eastern countries such as Bulgaria and Slovakia, ECEC attendance of under 3-year-olds is rather rare (5–21%). Much higher attendance of under-3-year-olds can be found in Scandinavian countries such as Sweden (58%) and Denmark (63%), as well as in Luxembourg, where 57% of under-3-year-olds attended ECEC in 2024 (Eurostat, 2024). As the EU targets to achieve a 96% ECEC attendance rates for children over the age of 3 (Council of the European Union, 2021), the ECEC attendance for this age group varies less between countries, with a range from 73% to 100% attendance in 2024 (Eurostat, 2024).

3.2.1 Differences by Family Background

Disadvantaged children have been found to attend ECEC services at a lower rate than other children. For example, children with a lower SES tend to attend ECEC at a lower rate than those with higher SES, as found by Flisi & Blasko (2019). This seems to be the case both in regard to family income and parental education (Büchner & Spieß, 2007; Sibley et al., 2015). A gap in attendance based on SES was found in nearly all OECD countries; however, it did not always reach significance (Cadima et al., 2020). Even if children with low SES attended ECEC, they were more likely to be enrolled in ECEC of lower quality than their peers with higher SES (see review on European studies, Vandenbroeck & Lazzari, 2014).

Similar tendencies might be assumed for other dimensions of disadvantage, such as migration background or home language. In regard to the intensity of ECEC attendance (in weekly hours), no definite differences based on migration background could be found based on EU data (Ünver et al., 2021). However, a 2019 study in Flanders, Belgium, showed that families with a migration background used ECEC only half as often as native families (56% vs. 92%). They also reported a higher need for formal ECEC as care by grandparents was restricted due to geographical distance (Teppers et al., 2019). In a similar fashion, children with non-Western migration status also were less likely than their native peers to attend ECEC in Norway before the age of 18 months (Zachrisson et al., 2013). In the US, a similar attendance gap between children whose mother was not born in the country or did not speak English at home and their peers was found over several datasets (Karoly & Gonzalez, 2011).

The findings on the ECEC attendance gap are extended by an Australian study which shows that ECEC services used by families with a migration or non-English language background are more likely to be of lower quality those used by native and English-speaking families (Tang et al., 2024). The authors suggest that besides geographical and access related reasons, social factors such as knowledge of the local education system, language barriers and social networks may explain this pattern.

3.2.2 ECEC Attendance in Luxembourg

Due to two mandatory preschool years since 1992 and 20 free childcare hours since 2017, ECEC attendance in Luxembourg is generally high (Bousselin, 2019; Honig et al., 2015).

In 2021, only 2.9% of children aged 3 to 6 did not participate in ISCED-02, i.e., voluntary or mandatory preschool (Eurostat, 2024). This places Luxembourg among the EU countries with the highest ECEC attendance rates. The high participation is largely due to the mandatory preschool years for children aged 4 to 6 and a highly popular voluntary preschool year, which tends to enroll over 70% of children at age 3 (MENJE & SCRIPT, 2024).

For children under the age of 3, participation in early childcare is more than double the OECD average (OECD, 2022b). In 2021, 63% of children in this age group were enrolled in early childcare (Eurostat, 2024). A significant share of this care is provided by commercial, for-profit providers: in 2023, nearly 50% of children under four attended commercial settings, while 15–20% were in publicly funded care (OECD, 2022b; Simoes Loureiro & Neumann, 2024). The remainder did not attend childcare.

Importantly, in Luxembourg, ECEC attendance—defined broadly to include *Cycle 1, précoce*, *crèches*, and *Dageselteren*—did not significantly vary by SES or maternal education background, while this was not the case for many other European countries (Flisi & Blasko, 2019). Similarly, Bousselin (2019) found no subgroup-specific effects of the 2009 childcare reform on participation rates.

3.3 ECEC and Academic Achievement

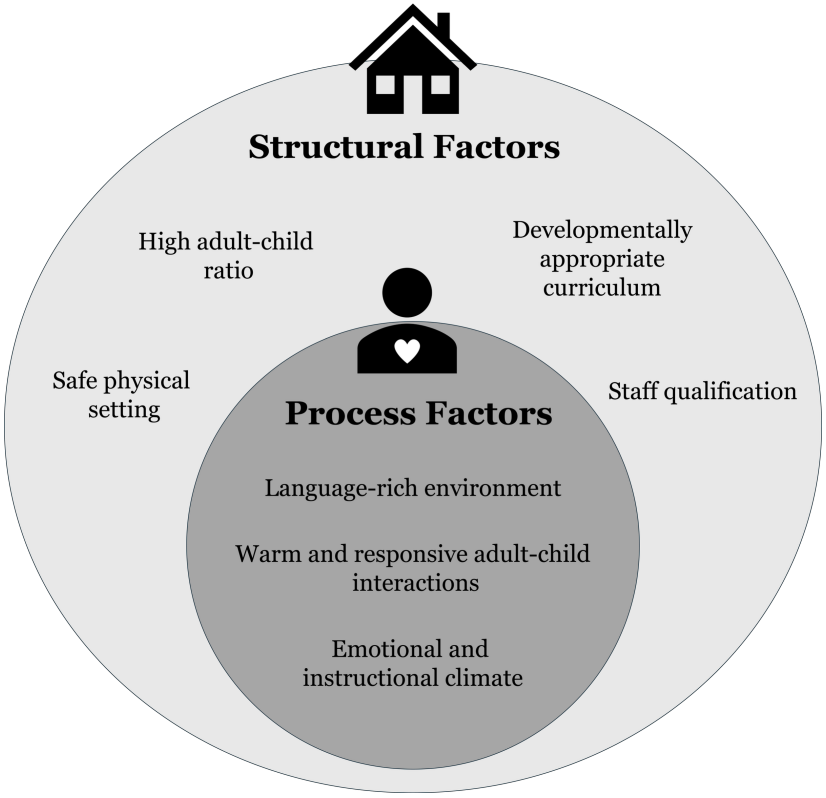
Attendance in ECEC has been positively linked to a range of cognitive outcomes and achievement indicators, including mathematics, reading, and language skills (Bennett, 2012; Camilli et al., 2010; Lazzari & Vandenbroeck, 2013). Nevertheless, there are many factors this association depends on: Benefits have been found especially in regard to high-quality ECEC settings, which may be why differences appear between different types of ECEC (Melhuish et al., 2015). Effects also depend on the dosage, the age of entry, duration, and intensity (W. Li et al., 2020; van Huizen & Plantenga, 2018; Wasik & Snell, 2019). Most importantly, effects also differ between student populations, with often greater benefits for disadvantaged groups (Lazzari & Vandenbroeck, 2013; Melhuish, 2004). These differences are explored in more detail in the subchapters below.

3.3.1 Quality as a Key Condition for ECEC Benefits

Quality of ECEC seems to be a key determinant for the effects of attending an ECEC service. While attending low-quality services can be detrimental to the children's development, high-quality ECEC has been consistently connected to favorable academic and other developmental outcomes (Cadima et al., 2020; Lazzari & Vandenbroeck, 2013; van Huizen & Plantenga, 2018).

As illustrated in Figure 2, ECEC quality is often divided into structural quality and process quality (Y. Anders et al., 2013; Vandenbroeck, 2020). Structural quality encompasses aspects that may be regulated at a policy level such as child-staff ratios (Taguma et al., 2012),

Figure 2. *Quality factors for ECEC*



Note. Adapted from Center on the Developing Child (2016).

appropriate curricula (Laevers, 2005; Wasik & Snell, 2019), and the availability of educational resources in the location. Process quality refers to aspects of the interaction between staff and children, for example, warmth (Harms et al., 2014; Oades-Sese & Li, 2011), responsiveness (Cadima et al., 2020), or domain-specific instructional quality (Y. Anders et al., 2013). These elements are conceptually reflected in "moment-to-moment displays of discrete behaviors as well as global characterizations of the overall setting" (Pianta et al., 2005, p. 145).

Structural quality is generally thought to impact child development indirectly, as it is a necessary but not sufficient condition that enables educators and caretakers to realize high process quality (NICHD Early Child Care Research Network, 2002; Soliday Hong et al., 2019). Fittingly, aspects of the structural and process quality have indeed been found to be related (Howes et al., 1995; Pianta et al., 2005; Slot, 2018), and process quality was found to mediate the effect of structural quality on the cognitive development (NICHD Early Child Care Research Network, 2002).

Process quality, on the other hand, has repeatedly and per definition been identified as a direct influence on child development and key element for the benefits of ECEC (Kluczniok & Roßbach, 2014; Ulferts et al., 2019). In several meta-analyses, process quality in ECEC was shown to have small but lasting associations with academic achievement (see for the US, Soliday Hong et al., 2019; and for Europe, Ulferts et al., 2019; Von Suchodoletz et al., 2023). However, researchers still debate whether (and which) individual aspects of quality predict the effectiveness of ECEC more strongly than a composite quality score (Howard et al., 2024; Slot, 2018; Soliday Hong et al., 2019; Von Suchodoletz et al., 2023).

Whether quality is more important for ECEC benefits in certain populations is uncertain. Bustamante and colleagues (2022) showed that children from low SES families especially benefitted from time in high-quality ECEC, coming close to eliminating the salary gap between them and advantaged peers after a sufficient time in high-quality care. In contrast,

a recent meta-analysis did not find significant moderations of the quality impact by socioeconomic or migration background (Von Suchodoletz et al., 2023). Other researchers have pointed out that some language groups, such as bilingual children, benefit in their language development from certain accommodations, such as support for their home language, explicit vocabulary instruction, qualified staff that speak children's first language as well as bilingual books and other resources in the classroom (Castro et al., 2011). Other studies also found that bilingual children especially benefit from emotional support within process quality, i.e., interaction quality in ECEC (Willard et al., 2021) or certain linguistic characteristics, such as teachers using shorter sentences (Bowers & Vasilyeva, 2011). This was not observed in monolingual children in these studies.

3.3.2 Differences Between ECEC Systems and The Advantage of Unitary Programs

Research suggests that universal ECEC systems, offering high-quality provision to all children regardless of background but paying special attention to disadvantaged students (e.g., low SES) tend to produce more favorable outcomes than systems targeting only disadvantaged populations (see Bennett, 2012; Cascio, 2019). This finding might go back to two main drawbacks of targeted provision. First, targeted ECEC may reinforce social and ethnic segregation and limit opportunities for peer learning, thus reducing overall effectiveness compared to more inclusive models (Barnett & Nores, 2015). Second, such programs tend to suffer from insufficient funding due to limited public and political support, leading to the notion that "programs for the poor are poor programs" (Cascio, 2019, p. 1). In contrast, universal programs have a larger number of stakeholders, which enables greater public support and concern for maintaining sufficient quality (Barnett & Nores, 2015; Cascio, 2019).

Additionally, unitary (or "unified") ECEC systems have been repeatedly found more beneficial than separate or fragmented programs (Esping-Andersen et al., 2012; Lazzari & Vandenbroeck, 2013), especially in the first years of ECEC (Del Boca et al., 2022). Unitary

systems, as seen in Scandinavian countries, are characterized by settings that cover the entire age range from birth to formal schooling at age 6 and include both care and education aspects. In contrast, separate systems, as found in Luxembourg, Belgium, and the Netherlands, offer split settings between the ISCED-01 and ISCED-02 levels. To younger children in these systems, non-formal childcare with less focus on education is provided, while older children, after a transition at the age of three, participate in more formal educational settings designed to prepare them for primary school (Del Boca et al., 2022; Vandenbroeck, 2020). This separation is often accompanied by separate regulatory frameworks, multiple governing authorities, privatization, and disparities in both access and quality of the provision (Vandenbroeck et al., 2018).

3.3.3 Differences Between ECEC Types and the Problem of Private Provision

Generally, ECEC for older children (ISCED-02) is supported by more literature showing consistent positive outcomes (e.g., in regard to academic achievement, cognitive and language development) than early childcare services for younger children under the age of 3 (ISCED-01). The latter has been investigated less frequently and yielded more mixed results in which effects depended on student population and ECEC quality (see reviews by Bensel & Haug-Schnabel, 2018; Melhuish et al., 2015). Possibly, these findings may be linked to the previously described separate ECEC systems, where early childcare services (ISCED-01) tend to fall under different regulations than services for older children (ISCED-02). In many countries, for example, France and Luxembourg, early childcare is more frequently provided by private actors and governed by non-educational authorities, whereas ISCED-02 services are more likely to be publicly funded (OECD, 2022b; Schreyer & Oberhuemer, 2024).

Private or mixed programs tend to be less beneficial than public programs, as shown for a composite score across various developmental domains (see meta-analysis by van Huizen & Plantenga, 2018) and short-term academic achievement in children aged 5 to 6 (Ansari et

al., 2021). The privatization and marketization of childcare has been historically framed as a way to balance quality and affordability, due to parents' freedom to critically choose the best childcare for their children (Vandenbroeck, 2020; Vandenbroeck et al., 2021). However, this assumption does not seem to hold. Because staff costs constitute the largest share of ECEC expenditures, private providers often reduce staffing expenses to increase profitability, which directly compromises the quality of care (Vandenbroeck et al., 2021). Moreover, parents cannot judge the quality of ECEC care when they are absent; thus, they have been found to overestimate ECEC quality or rely on other indicators when selecting providers (Grammatikopoulos et al., 2014; Janssen et al., 2021; Mocan, 2007). Taken together, this indicates that differences in benefits of united versus separate systems, ECEC types for younger versus older children and public versus private provision are intercorrelated and go back to quality as key factor for ECEC effects.

3.3.4 No Clear Patterns Depending on the Outcome Domain

Many of the research articles exploring the link between ECEC attendance and academic achievement examine more than one outcome domain. In the early years, commonly investigated outcomes include early literacy, receptive vocabulary, and early numeracy. They are often measured by standardized tests, such as the Woodcock-Johnson Tests of Achievement (Woodcock, 1989). Among older students, studies frequently focus on mathematics and reading achievement based on, for example, national school monitoring data or international assessments like PISA. Additionally, researchers have considered broader indicators of educational success and trajectories, such as grade retention or graduation rates.

In a large proportion of studies, no substantial differences were observed between achievement domains such as language, literacy, and mathematics. For example, Driessen et al. (2004) report minimal and nearly negligible associations of ECEC attendance with both mathematics and language outcomes measured at ages 6, 8, and 10 within the fragmented

ECEC system of the Netherlands, with no discernible differences between the two domains. Similarly, in Australia's heterogeneous ECEC landscape, only 1% of the variance in national monitoring scores for mathematics and reading from Grades 3 to 9 could be explained by ECEC attendance, again showing no systematic difference between the domains (Little et al., 2020). Norway's more unified ECEC system revealed that a lottery offer for early entry into ECEC, as opposed to late entry, was associated with significant gains in both mathematics and language at age 6 to 7, with no differences between the two domains (Drange & Havnes, 2019).

Looking beyond these three selected studies, a slightly different picture of domain differences emerges from several U.S.-based studies, examining a range of ECEC types—from center-based childcare for infants to preschool programs at the age of five. They either found similarly positive associations with both mathematics and reading outcomes (Ansari et al., 2021; Esping-Andersen et al., 2012; Le et al., 2006; Loeb et al., 2007; Rathburn & Zhang, 2016), or observed stronger or more consistent associations with literacy and reading compared to mathematics (Pion & Lipsey, 2021; Wong et al., 2008). This pattern is also supported by a study of PISA scores across 14 European countries, showing that additional years spent in ECEC were most strongly associated with reading than with mathematics and science (Del Boca et al., 2022). Additionally, several U.S.-based studies found the weakest associations of ECEC attendance in relation to language outcomes (Pion & Lipsey, 2021; Skibbe et al., 2013; Votruba-Drzal et al., 2015; Wong et al., 2008).

However, there is also evidence for the opposite pattern. A body of research highlights stronger associations between ECEC attendance and outcomes in science or mathematics, rather than reading or writing. For example, Sierens et al. (2020) found science to be more strongly linked to ECEC participation than reading within Belgium’s heterogeneous ECEC system. Similarly, other studies reported mathematics as the domain most positively affected by ECEC attendance (Cortázar, 2015; Peisner-Feinberg et al., 2017). These findings span

diverse ECEC contexts, from a U.S. state-funded pre-K program for 4-year-olds (Peisner-Feinberg et al., 2017) to an expanded, publicly funded ECEC program in Chile (Cortázar, 2015).

Findings also suggest that ECEC benefits extend beyond academic achievement towards broader educational outcomes, as attendance is consistently associated with reduced grade retention over several educational settings. For example, a recent evaluation of Chile's public ECEC program (Cortázar et al., 2020) shows that in comparison to children with no ECEC experience, participation in the program was associated with a 5.1% reduction in grade retention, an 18.4% decrease in dropout rates, and a 13.3% increase in on-time-graduations. These associations were notably stronger than those found in Spain, where public childcare for 3-year-olds was linked to only a 2.5% reduction in grade retention (Felfe et al., 2015). In the United States, a meta-analysis on classroom-based ECEC programs for children under five similarly reported significant improvements in educational trajectories, with reductions in grade retention and increases in high school graduation rates, showing moderate to high effect sizes ranging from d = 0.24 to 0.26 (McCoy et al., 2017).

All in all, studies suggest that there is no consistent pattern regarding which academic domains are most strongly influenced by ECEC attendance. Instead, patterns may vary between assessment years (Xue et al., 2016), estimation methods (Zachrisson et al., 2024), and ECEC systems and types. This variability is further emphasized by Sammons et al. (2002), who indicate that which outcome might benefit most might vary even within individual ECEC centers.

3.3.5 Fadeout of ECEC Effects and Conditions for Persistence

A substantial body of research has investigated whether, and under what conditions, the beneficial short-term effects of ECEC may persist beyond the early school years and continue to benefit individuals and societies in the long term, rather than fading out over time, as

outcomes of ECEC attendees and non-attendees converge (Bailey et al., 2017; Yoshikawa et al., 2013).

Crucially, the persistence of ECEC effects seems to depend on the quality of the ECEC provision. For instance, an OECD report (2011) found that associations between preschool and PISA reading scores at age 15 were stronger in countries that offered childcare to a larger population, had smaller child-to-staff ratios, and invested more per child in ECEC.

Furthermore, ECEC benefits seem to persist longer in unitary ECEC systems than in separate systems (Del Boca et al., 2022; Esping-Andersen et al., 2012). Evidence of sustained ECEC effects in unitary systems includes improved academic achievement at age 11 in Norway (Zachrisson et al., 2024) and Denmark (Esping-Andersen et al., 2012), at age 13 in Sweden (Andersson, 1992), as well as a beneficial impact on the attended school track at age 14 in Germany (Büchner & Spieß, 2007). Notably, a study by Havnes and Mogstad (2009) showed that the expansion of Norway's unitary ECEC system still had significant impacts on educational trajectories and earnings measured by the age of 30.

In separate and heterogenous ECEC systems, such as the United States and the Netherlands, research on both targeted and universal ECEC found that gains in academic achievement and cognitive skills could not be found in the long-term or were greatest immediately after the end of the program but diminished rapidly in the subsequent years (Driessen, 2004; Esping-Andersen et al., 2012; Han & Neuharth-Pritchett, 2021; Lipsey et al., 2018; Puma et al., 2012). A meta-analysis by Aos et al. (2004) on targeted ECEC programs in the United States even modeled a decline in effect sizes from +0.40 to just +0.16 *SD* by the end of high school, illustrating the extent of this fadeout.

Counterintuitively, some of the rigorous early childhood interventions in the United States have shown a pattern where initial benefits fade quickly, yet long-term impacts on attainment and other outcomes re-emerge in adulthood (Bailey et al., 2017; Yoshikawa et al.,

2013). These long-term benefits include both real-world outcomes, such as higher salaries and increased college graduation rates (Bustamante et al., 2022), as well as educational outcomes, such as reduced grade retention and higher high school graduation rates, shown in a meta-analysis by McCoy et al. (2017).

In the attempt to explain this seemingly paradoxical phenomenon, Bailey et al. (2017) outline a potential mechanism along with three key conditions for the persistence of ECEC effects in the long run.

First, ECEC effects are more persistent if children have the opportunity to learn fundamental skills, behaviors, and beliefs in ECEC that they would not have developed otherwise. These include, for example, advanced literacy and communication skills, academic motivation, or—for children growing up in adversity—emotional self-regulation.

Second, persistence is more likely if ECEC helps children to "get a foot in the door" at critical moments, by averting risks such as grade retention, or seizing opportunities, such as entering a more advantageous school track. Early competences developed in ECEC may therefore influence later skills directly ("skill-begets-skill") or indirectly via foot-in-the-door processes and the opportunities that open up through the new environments or circumstances—a process described as “developmental cascades” (Bailey et al., 2017, p. 21).

Last but not least, the persistence of ECEC effects depends on the quality and alignment of subsequent learning environments. For early gains to be sustained, primary education must reinforce and build upon the skills acquired in ECEC. This includes ensuring curricular continuity, for example, avoiding unnecessary repetition of content, and promoting high classroom quality in primary school (Ansari & Pianta, 2018; Shuey et al., 2019; Stipek et al., 2017).

Based on these mechanisms, findings of rapid fade-out, but persistence of ECEC effects in adulthood may go back to mediocre classroom quality in the US, hindering the development

of academic achievement in high school. At the same time, skill building and foot-in-the-door effects of ECEC may have strengthened non-cognitive competencies and beliefs and prevented detrimental events such as grade retention. This dynamic may have circumvented negative developmental cascades, and, thus, led to more positive outcomes in adulthood.

3.3.6 The Role of Dosage and its Dependence on Content and Children's Characteristics

An important aspect to consider when evaluating ECEC effectiveness is dosage. Dosage refers to the amount of exposure children have to an ECEC program, which can be assessed in multiple ways. Most commonly, researchers examine duration (in years) and intensity (in hours per week). Less frequently studied dimensions include absences from the program, time allocated to specific instructional activities, and accumulated dosage (a combination of duration and intensity) (Xue et al., 2016)5.

Just as in medicine, a sufficient dosage of ECEC is needed to benefit children's development. Bennett (2012) even describes an insufficient duration or intensity of preschool as one of the three main impediments to children's learning in ECEC. In line with this, a longer duration or an earlier start in ECEC services has been linked to better cognitive development and language skills in infancy (Barnes & Melhuish, 2017; L. M. Berger et al., 2021), better academic achievement at school entry (Drange & Havnes, 2019; Sammons et al., 2004), sustained academic benefits at ages 8 and 13 (Andersson, 1992), more favorable school track placement in secondary school (Büchner & Spieß, 2007), and even a higher likelihood of college graduation (Bustamante et al., 2022).

In contrast, a meta-analysis examining a composite score across various developmental domains found no significant effect of age of entry into ECEC. Instead, it highlighted the positive impact of higher intensity (van Huizen & Plantenga, 2018). The importance of

[5] Different aspects of dosage may connect to child outcomes in distinct ways. A study employing propensity-score matching on larger U.S.-progams found larger gains for longer duration and more time spent on specific instruction, partly larger gains for fewer absences, and no consistent gains for higher intensity (Xue et al., 2016).

intensity is echoed in a UK-based study on early childcare (ages 0–4), which reports that more hours in childcare before the age of 4 are associated with better cognitive development during infancy (Barnes & Melhuish, 2017).

Sufficient dosage of ECEC attendance appears particularly important for disadvantaged subgroups. For instance, there is evidence suggesting that bilingual children might especially benefit from early entry and longer duration in ECEC (Soliday Hong et al., 2023; Yazejian et al., 2015). Furthermore, a high-intensity childcare program in Canada (over 35 hours a week) showed benefits exclusively for children from low-SES families, regardless of the age at which they entered the program. However, those who started earlier experienced even greater gains, with academic outcomes reaching levels comparable to their high-SES peers (Laurin et al., 2015). Similarly, a U.S. review of preschool program dosage (ages 3 to 6, ISCED-02) indicated that vulnerable populations benefit especially from more time in preschool programs (Wasik & Snell, 2019). At the same time, not all studies found a clear moderation effect based on SES (e.g., Loeb et al., 2007).

While these studies illustrate that sufficient dosage mostly seems to be necessary for noticeable effects on children's development, other critical conditions for ECEC effectiveness—most notably, high-quality provision—should not be neglected (Lazzari & Vandenbroeck, 2013). Quality might help to explain why some findings from more fragmented ECEC systems with heterogeneous quality show limited or mixed evidence regarding the impact of dosage, such as studies from the Netherlands (Driessen, 2004), and Australia (Lim et al., 2022; Little et al., 2020).

Furthermore, the question of "how much ECEC is sufficient" cannot be answered without considering "how much of what", as dosage effects closely depend on the curriculum content of ECEC programs (Wasik & Snell, 2019). This consideration is key to understanding the counterintuitive findings of Li et al (2020). In their meta-analysis, they report larger effect

sizes for ECEC programs starting in infancy, while finding smaller effect sizes for programs with longer duration. When accounting for the interplay of dosage and content, these findings suggest that children may generally benefit from an earlier start, but eventually "max out" (Wasik & Snell, 2019, p. 35) on the developmental gains offered by a specific curriculum. At this point, transitioning to the subsequent ECEC program for older age groups might be more beneficial.

Fittingly, several studies on dosage effects reveal curvilinear associations, indicating there may also be a "too much" of a ECEC program. For example, across 14 European studies, a medium duration (3–4 years) of ECEC attendance was linked to the highest PISA scores in reading, mathematics, and science (Del Boca et al., 2022), suggesting an optimal starting age between 1 and 3 years. This aligns with research from the United States (Loeb et al., 2007), in which age of entry was in a nonlinear relationship with short-term language development, peaking at age 2 to 3. Further support comes from the longitudinal EPPSE/EPPNI[6] study in the United Kingdom, which found that each additional month of ECEC attendance before the age of 3 was associated with better cognitive development, while starting before the age of 2 did not have an additional benefits (Sylva et al., 2004). Notably, many of the studies reporting linear effects focused exclusively on ECEC programs for older children (ages 3 to 6, ISCED-02), meaning that nonlinear relationships may not have been detectable or considered in those contexts.

These nonlinear effects, along with findings indicating fewer benefits for children under the age of 2, may reflect the particular need for and lack of high-quality care for the youngest (Bock-Famulla, 2009; Fort et al., 2016; Melhuish, 2004). ECEC provision in infancy remains a highly debated and emotionally charged topic, with contrasting perspectives in the scientific

[6] EPPSE stands for *Effective pre-school, primary and secondary education*, while EPPNI stands for *Effective pre-school provision in Northern Ireland*.

literature (cp., Bensel & Haug-Schnabel, 2018; Rey-Guerra et al., 2023). Concerningly, some studies have reported an increased level of behavioral problems[7] associated with higher ECEC dosage at very early ages (e.g., L. M. Berger et al., 2021; Bradley & Vandell, 2007; Coley et al., 2013). However, this association tends to diminish when quality of care is taken into account (Huston et al., 2015; Rey-Guerra et al., 2023).

3.3.7 Stronger ECEC Benefits for Disadvantaged Students

One of the strongest and most consistent findings in ECEC literature is that disadvantaged children benefit more from attendance in ECEC than their advantaged peers (see reviews, Bennett, 2012; Lazzari & Vandenbroeck, 2013; Melhuish, 2004; Ruhm & Waldfogel, 2012).

This has been found in regard to *SES* in both short- and long-term studies across a large variety of countries, types of ECEC, and academic outcomes (Ansari et al., 2021; Davies et al., 2021; Felfe et al., 2015; Felfe & Lalive, 2014; Larose et al., 2021; Loeb et al., 2007). Notably, in Norway, the SES gap in language achievement at ages 6 to 7 was reduced by half when children attended childcare early, as the most pronounced effects were observed among lower-performing children (Drange & Havnes, 2019). Similarly, in Canada, ECEC attendance was significantly associated with achievement at ages 6 to 7 only among children from low-SES backgrounds (Geoffroy et al., 2010), indicating that ECEC attendance might help mitigate early disparities based on family background. Long-term outcomes similarly follow this pattern: in the United States, more time spent in ECEC was associated with reduced gaps in college graduation rates among children from low-income families (Bustamante et al., 2022). Comparable moderating effects of SES on adult outcomes were found in Norway (Havnes & Mogstad, 2009).

[7] As the focus of this thesis lies on academic achievement, behavioral problems and other non-cognitive outcomes are largely excluded in the literature review. Due to the significant concerns surrounding dosage and age of entry in relation to behavioral development, this topic is briefly addressed here as an exception.

Interestingly, findings from the two Chilean studies by Cortazar et al. (2015; 2020) indicate that ECEC attenders of middle and middle-to-low SES showed the greatest gains in their Grade 4 achievement scores. In contrast, children from the lowest income group, representing the poorest 8%, as well as those living in rural areas, seemed to benefit less than their respective peers. The authors suggest that these groups may have not had access to ECEC with sufficient quality to yield meaningful benefits, as results pointed towards disparities in the quality between rural and urban ECEC centers.

Whether and how SES moderates the relationship between ECEC and achievement can also depend on how SES is assessed. Common indicators are, for example, parental education, occupational status of parents, or family income. Zachrisson et al. (2024) found that ECEC was more strongly associated with improved mathematics and reading outcomes at age 10 for children whose parents had lower levels of education, but not for those with lower-income families. The authors speculate whether this might be a pattern specific to Norway where parental income and education are less closely correlated than in the United States.

Moderating effects of children's backgrounds have also been observed in relation to *migration* background, with stronger benefits of ECEC on achievement outcomes for children from immigrant families (D. Foster, 2025; see review, Lazzari & Vandenbroeck, 2013). Here, much of the existing research comes from European contexts, including German studies on school readiness (Cornelissen et al., 2018; Felfe & Lalive, 2014) and school track placements (Spiess et al., 2003), as well as French studies on early language development (L. M. Berger et al., 2021; Caille, 2001). A comprehensive U.S.-based study by Votruba-Drzal (2015) further supports these findings, showing that children from immigrant families experienced twice the gains in language, reading, and mathematics at age 5 compared to their non-immigrant peers. The effect sizes were substantial enough to nearly eliminate skill gaps between children with and without a migration background. Interestingly, home language of immigrant families

moderated these associations in contrasting directions. Immigrant children speaking English at home showed stronger gains in mathematics, while those not speaking English at home benefited stronger in language skills. One possible explanation is that the language skills of non-English-speaking children may not have been sufficiently developed to benefit from instruction in mathematics. However, the language-rich environment of ECEC settings likely contributed to significant improvements in their language development.

Looking at the role of *home language* in more detail, stronger associations between ECEC attendance and academic achievement has also been observed for children who speak a language at home that differs from the language of instruction. For example, in the United States, bilingual children showed greater gains in language skills compared to monolingual peers after an early start in a high-quality, targeted ECEC program (Soliday Hong et al., 2023; Yazejian et al., 2015). Similar findings emerged from studies on public ECEC programs for 4-year-olds where bilinguals demonstrated greater short-term gains in literacy, language and mathematics by age 5 compared to their monolingual peers (Ansari et al., 2021; Pion & Lipsey, 2021). However, earlier research on comparable programs found that such initial advantages did not persist when examining grade retention by third grade (Lipsey et al., 2018). In North Carolina, however, even short-term academic benefits of a pre-kindergarten program could not be found for bilingual children (Peisner-Feinberg et al., 2017), instead, they only seemed to benefit in other outcomes, such as executive function.

The heterogeneous findings may potentially be explained by the level of exposure bilingual children have to the language of instruction. In a German study by Kohl et al. (2019), early entry into ECEC was generally associated with higher receptive language skills in German. The association was particularly strong for bilingual students with low exposure to German at home compared to both monolingual children and bilingual peers who spoke German at home. As such, early entry into ECEC narrowed the gap between language groups.

For bilingual children with limited exposure to the language of instruction, extended time with this language and, in the best case, a rich language environment in ECEC can thus significantly promote development in that language, thereby indirectly supporting academic achievement. The role of ECEC becomes even more crucial if parents lack the resources to provide a similarly stimulating experience in the language of instruction at home (Hoff et al., 2020). Fittingly, the interaction quality in ECEC was observed to be particularly important for the development of majority language skills in multilingual children (Willard et al., 2021).

While a majority of studies highlight the benefits of ECEC for disadvantaged children, the existence and persistence of these moderated effects are not guaranteed. Esping-Andersen et al. (2012) compared data from Denmark and the United States, finding that only Denmark's more effective and universal ECEC system was associated with increased equity in reading scores at age 11 following ECEC attendance at age 3. In contrast, initial advantages for disadvantaged children in the United States, where the services are often privatized and quality of ECEC is dependent on family background, appeared to diminish by Grade 5. Similar findings of limited or absent benefits for disadvantaged children have been reported in other studies. For example, U.S.-based research (Han & Neuharth-Pritchett, 2021; Vandell et al., 2010) on achievement in adolescence and a study from the Netherlands (Luijk et al., 2015), looking at language outcomes up to age 6, failed to detect significant moderating effect by SES or migration background.

Even more troubling than the lack of moderation effects in some studies is the rarer phenomenon of advantaged children benefitting more from ECEC than their disadvantaged peers, often described as a Matthew effect (“unto every one that hath shall be given”, see Bonoli et al., 2017). Such an effect was found, for example, in regard to SES and PISA mathematics scores in Portugal (D. Foster, 2025) and may potentially be confounded with the inequal accessibility of high-quality ECEC (Mathers & Smees, 2014; OECD, 2025).

All in all, most research strongly points towards the potential of disadvantaged groups (with low SES, a migration background, or other home languages) benefitting most from ECEC attendance, however, moderations also depend crucially on children's characteristics, concrete outcomes and the ECEC system, with more consistent benefits in unitary systems providing universal and high-quality ECEC.

4 The Present Thesis

Characterized by a linguistically diverse student population, Luxembourg faces persistent and distinct educational disparities both in student achievement data in large-scale assessments (Hornung et al., 2023; SCRIPT, 2020; Sonnleitner et al., 2021) and in administrative data on grade retention, track placements, and school dropouts (Backes & Hadjar, 2024). This highlights the urgent need for effective policy-level strategies to ensure equal educational opportunities for all children.

Extensive international research has demonstrated the potential of ECEC to especially promote the academic achievement and educational trajectories of disadvantaged students, thereby helping to reduce achievement gaps and systemic educational inequalities. However, the effectiveness of ECEC is closely tied to specific characteristics of its system and provision. To date, no systematic study has examined ECEC attendance in Luxembourg, its relationship with academic achievement, and its potential in reducing disparities between student groups. Using secondary data from the high-quality Luxembourg School Monitoring Programme *Épreuves Standardisées* (ÉpStan; Martin et al., 2015), this thesis aims to uncover new knowledge relevant to Luxembourgish educational policy and research. Given the unique features of the Luxembourgish ECEC system, including its inherent multilingualism, notably high government funding, and a highly heterogeneous and fragmented structure across providers and types, the thesis at the same time aims to contribute a valuable puzzle piece to international ECEC research. Due to the growing relevance of multilingualism in a globalized society (Grosjean, 2018; Hong & Cheon, 2017), and “the kaleidoscope of diversities [that] is here to stay” (Vandenbroeck, 2018, p. 411), the highly multilingual setting of Luxembourg may provide a helpful "living laboratory" (Emslander, 2024) for other settings around the world.

Five central research interests encouraged four studies that form the present thesis. In Figure 3, the four studies are described in terms of their sample, design, variables, method, and contribution to the investigation of each research interest, to show their thematic overlap. Additionally, the figure shows each study's publication status.

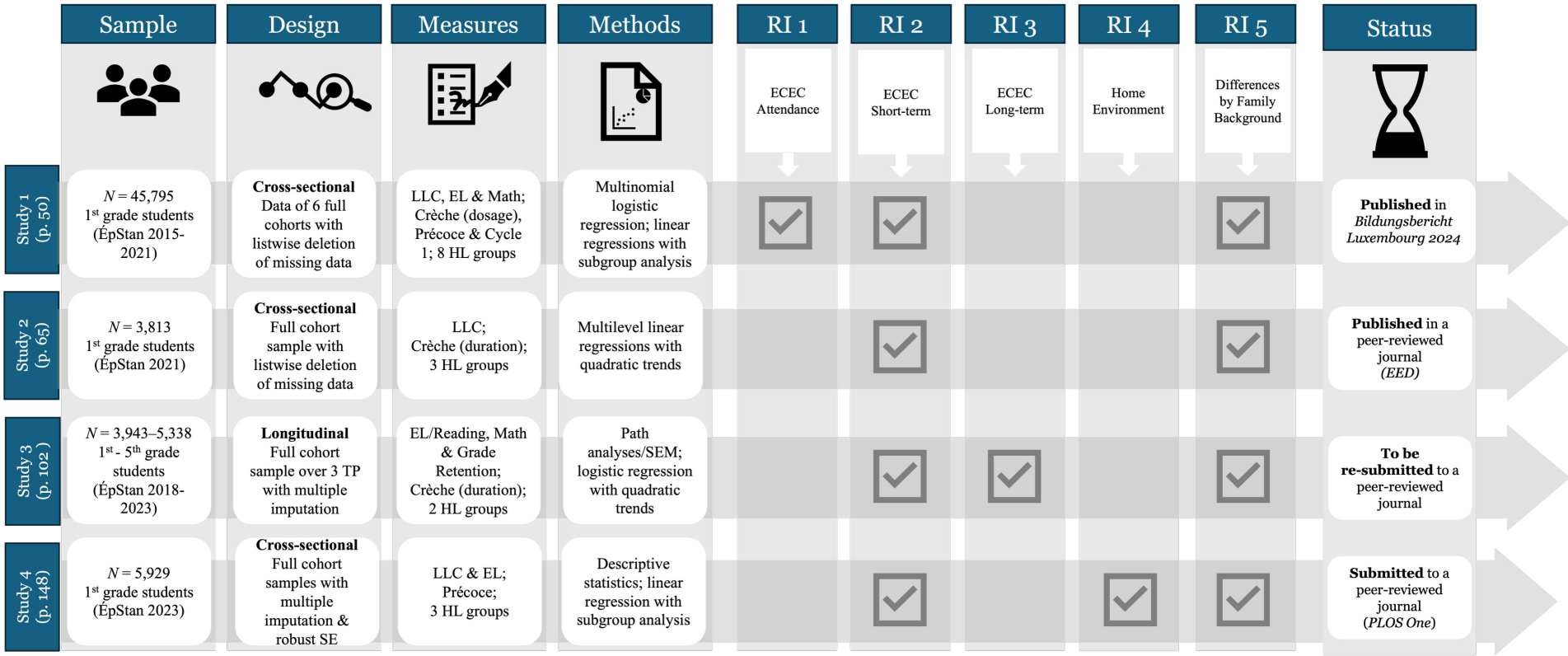
Subsequently, the five research interests of this thesis and four papers will be described in more detail in chapters 7.1 and 7.2. As RI 5 (differences by family background) represents a sub-aspect of all other research interests, considerations on RI 5 will be introduced in conjunction with RI 1 to 4.

4.1 Research Interests

RI 1—ECEC Attendance

Attendance in ECEC generally varies based on type of setting, age of the child, and family background, with higher attendance rates observed in preschool settings and among older age groups (ISCED-02; see Eurostat, 2024). However, the attendance literature also suggests disparities whereby children from disadvantaged backgrounds—those that would benefit most from ECEC attendance—are less likely to attend ECEC (Bonoli et al., 2017; Flisi & Blasko, 2019). Disparities in ECEC attendance based on SES (Cadima et al., 2020; Sibley et al., 2015), migration background (Tang et al., 2024; Teppers et al., 2019), or home language (Tang et al., 2024) may be linked to lower service availability or quality in disadvantaged areas (Mathers & Smees, 2014; OECD, 2025). In Luxembourg, where the ECEC system is both highly subsidized and fragmented, existing research based on administrative data indicates generally high attendance rates—63% in childcare and 97% in preschool in 2021 (Eurostat, 2024). Nonetheless, more granular data on aspects such as childcare dosage have been missing from the previous studies. Here, parent reports represent a valuable yet generally underexplored data source in ECEC research.

Figure 3. *A systematic overview of the four included studies in the present doctoral thesis, including their methodological approach, research interests, and publication status*



Note. RI = Research Interest, Figure 3 is graphically adapted from Colling (2022).

Parent questionnaires within Luxembourg's school monitoring programme offer the opportunity to investigate ECEC attendance in childcare and voluntary preschool, average durations and intensities of attendance, languages spoken in childcare, and trends over the years.

RI 1 and RI 5—Differences by Family Background

Although existing research does not support the presence of attendance disparities in Luxembourg (Bousselin, 2019; Flisi & Blasko, 2019), previous studies were limited to preschool or aggregated ECEC data. As a result, they may not have been able to fully capture disparities across various types of ECEC provision. Analyses on parent-reported data of attendance and dosage of childcare and voluntary preschool, combined with information on SES, migration background, and home language, are conducted to provide critical insights into access and attendance disparities. This makes it possible to assess whether social disparities are present in Luxembourg's ECEC attendance rates and inform strategies to promote equitable access.

RI 2—ECEC and Short-Term Academic Achievement

So far, no studies have investigated the relationship between ECEC attendance and short-term academic achievement in Luxembourg. This gap represents a major blind spot, given the potential of ECEC for children's academic development in the early years. International research has suggested conditions under which ECEC can promote academic outcomes (Camilli et al., 2010; Lazzari & Vandenbroeck, 2012). These include high-quality care on a structural and process level (Manning et al., 2017; Ulferts et al., 2019), universal access for all children (Bennett, 2012; Cascio, 2019), unified ECEC programs spanning ages 0 to 6 in one setting (Esping-Andersen et al., 2012; Lazzari & Vandenbroeck, 2013), and public rather than private provision (van Huizen & Plantenga, 2018). Luxembourg's ECEC system

combines both aspects of more beneficial and less beneficial systems: While it offers universal coverage and high governmental subsidies, it is also highly fragmented and relies substantially on private childcare providers, which offer around 60% to 75% of the available childcare spots (Bollig et al., 2016; Honig et al., 2015; OECD, 2022b; OEJQS, 2025). Although no systematic assessment of ECEC quality in Luxembourg has been conducted in the field, the system's structure and curricular frameworks suggest considerable variation in quality, both between ECEC types and providers (OECD, 2022b). Thus, it is of particular interest to investigate whether different types of ECEC in Luxembourg are able to promote academic achievement despite this variability, or whether benefits are confined to specific types, outcomes, or amounts of ECEC dosage.

RI 2 and RI 5—Differences by Family Background

This thesis also seeks to explore whether potential benefits of ECEC in Luxembourg are amplified within or even limited to certain demographics, as disadvantaged children typically benefit more from ECEC than their more advantaged peers (Lazzari & Vandenbroeck, 2013; Melhuish, 2004; Ruhm & Waldfogel, 2012). These differential effects have been found in relation to SES (Felfe & Lalive, 2014; Larose et al., 2021), migration background (L. M. Berger et al., 2021; Votruba-Drzal et al., 2015), and home language (Ansari et al., 2021; Kohl et al., 2019). However, such moderation effects are less likely to emerge in fragmented and qualitatively heterogeneous ECEC systems (Caille, 2001; Luijk et al., 2015). As Luxembourg represents such a fragmented and heterogeneous system, the thesis aims to investigate whether the moderating effects of SES, migration background, and home language can be observed within the country. Demonstrating such moderating effects could underscore the role of ECEC in Luxembourg as an important tool for alleviating educational inequalities. Additionally, a special focus of the present thesis lies on the question of whether and for whom Luxembourg's unique and heterogeneous multilingual childcare system can replicate language acquisition

benefits for the language of instruction, similar to those observed in monolingual, immersion-based ECEC settings.

RI 3—ECEC and Long-Term Academic Achievement

Fadeout of ECEC benefits is a widely studied phenomenon. While some research finds persistent effects of ECEC that extend into later schooling and even adulthood (Bustamante et al., 2022; Del Boca et al., 2022), other studies report a rapid convergence of academic outcomes between ECEC attenders and non-attenders following initial gains (Puma et al., 2012). Cross-country comparisons indicate that unified ECEC systems are more likely to facilitate persistent effects than separate systems like in Luxembourg (Del Boca et al., 2022; Esping-Andersen et al., 2012). Bailey et al. (2017) empathize the importance of high-quality subsequent schooling and curricular alignment between ECEC and primary education as a key condition for sustainable ECEC gains. Although an OECD report classifies Luxembourg as highly aligned between preschool and primary school in terms of curricula and teacher qualifications (Shuey et al., 2019), this assessment does not take into account the lack of alignment between non-formal and formal ECEC and between language curricula in ECEC and primary school (OEJQS, 2025). Therefore, it is essential to examine whether any short-term associations of ECEC attendance and academic achievement in Luxembourg persist beyond first grade. In addition to long-term achievement in reading or mathematics, grade retention as a broader indicator of educational success is considered, as it may illustrate that ECEC contributes to foot-in-the-door processes (Bailey et al., 2017).

RI 3 and RI 5—Differences by Family Background:

Long-term ECEC associations with academic achievement have been found to be moderated by student background characteristics (Cortázar et al., 2020), with more sustained outcomes for disadvantaged students (Spiess et al., 2003; Zachrisson et al., 2024). However,

this pattern is found mostly in unitary ECEC contexts providing consistent high quality (Esping-Andersen et al., 2012). Thus, it is unclear if long-term outcomes of ECEC attendance would be moderated by family background in Luxembourg. The longitudinal monitoring dataset available for Luxembourg provides an interesting opportunity to examine potential moderations of ECEC associations with long-term academic achievement by student background characteristics.

RI 4—Home Environment

In addition to the role of early educational environments, the influence of the home environment needs to be considered. Family and home contexts are among the most powerful predictors of early development and academic success (Brushe et al., 2025; Hattie, 2010). Elements of the HLE, such as parental background, availability of resources, and parent-child interactions, and more specifically, aspects of the HLLE, such as language exposure and literacy practices, can significantly support or hinder children's academic achievement (M. A. Foster et al., 2005; Lehrl, Evangelou, et al., 2020; Linberg, Attig, et al., 2020). In the multilingual context of Luxembourg where over two-thirds of students do not speak the first of the three instructional languages (Luxembourgish) at home (MENJE & SCRIPT, 2024), it is particularly compelling to examine home environments, in particular, language and media exposure. Investigating how these factors of the home environment relate to early academic achievement, in particular, language and literacy development, could yield valuable insights and potentially inform interventions that support children's academic development.

RI 4 and RI 5—Differences by Family Background

The HLE has been found to mediate the relationship between SES and academic achievement (M. A. Foster et al., 2005; Jiang et al., 2024; Y. Li et al., 2025), which suggests it may serve a protective role. While most research has focused on the link between the HLE and

SES, some research also explores its relationship with home language (Dong & Chow, 2022). In Luxembourg, where home and school languages play a key role in educational disparities, it is of particular interest to investigate how HLLE environments differ across home language groups and how academic outcomes of different home language groups are associated with aspects of the HLLE, such as exposure to language and literacy activities, as well as other forms of media.

4.2 Research Objectives of the Included Studies

Study 1

Study 1 aims to broadly gain insight into the attendance of Luxembourg's ECEC system, its associations with academic achievement, as well as its potential to reduce achievement gaps between students of different backgrounds. For this, first-grade data of six full-population cohorts (N = 29,670) between 2015 and 2021[8] were investigated.

First, multinomial logistic regressions were applied to explore the attendance (RI 1) in two distinct types of ECEC in Luxembourg, early childcare and voluntary preschool. Early childcare was analyzed both in terms of attendance compared to non-attendance and in dosage, i.e., duration (in years) and intensity (in hours per week), whereas voluntary preschool was characterized by a fixed dosage. Given the heterogenous multilingual nature of non-formal ECEC in Luxembourg, Study 1 also examined the languages spoken in early childcare. Trends over the six assessment years were included. A particular emphasis was placed on attendance differences based on family characteristics (RI 5).

Second, Study 1 conducted linear regression analyses to examine the association between attending a specific combination of ECEC services and academic achievement in three domains, listening comprehension, early literacy, mathematics, as assessed in the first grade

[8] For dosage analyses, data was restricted to 2019 to 2021 as information on dosage was assessed from 2019 on. As ECEC attendance took place in the years prior to the first-grade assessment, our data covers cohorts enrolled in ECEC between 2009 and 2021.

(RI 2). The study also investigated the role of childcare dosage in regard to academic achievement. To explore whether ECEC attendance contributes to reducing achievement gaps, Study 1 also explored moderations based on family background characteristics such as SES, migration background, and home language (RI 5).

All analyses in Study 1 were conducted as multivariate regressions controlling for a range of potentially confounding variables. These included SES, migration background, home language, gender, previous grade retention, and assessment year. Lastly, to facilitate comparisons of effect sizes, standardized coefficients were estimated for both predictors and control variables.

Study 2

Building on the broad overview of ECEC attendance and its associations with three achievement domains in Study 1, the observation of a strong link to listening comprehension, but absence of a clear moderation pattern, motivated a more detailed investigation in Study 2. Using a full-population sample of N = 3,813 first graders from 2021, Study 2 explored how early childcare attendance was related to listening comprehension in Luxembourgish at the beginning of first grade (RI 2). Importantly, it investigated whether this relationship was moderated by home language group (RI 5), defined by whether students spoke Luxembourgish and/or German with their parents. Both attendance and duration of childcare were analyzed, with explicit attention to nonlinear effects. For this, multilevel regression analyses were conducted on large-scale school monitoring data, accounting for the nested data structure of students within classes and schools. To control for confounding background characteristics, age, gender, migration background, and SES were included as covariates.

Study 3

After focusing on short-term outcomes in the previous studies, Study 3 aimed to investigate the long-term associations (RI 3) of early childcare attendance and academic achievement from Grade 1 to Grade 5. To include a broader range of achievement indicators, but still keep the study focused, Study 3 investigated grade retention and tracked mathematics and reading skills longitudinally over multiple grades. Childcare dosage, represented as years in childcare, was explored alongside binary childcare attendance. Furthermore, potential moderating effects of SES and home language (RI 5) were investigated. These variables also served as covariates to account for confounding influences. Study 3 utilized data from a full-population cohort (N = 3,943–5,338) of students that entered first grade in 2018 and were assessed in every second grade after this. Missing data was handled with multiple imputation. Path analyses were conducted for mathematics and reading outcomes in Grades 1, 3, and 5, while logistic regression was used to examine grade retention. As the cohort experienced COVID-19 related school closures between their assessments, Study 3 also discusses implications and limitations arising from this period of disrupted learning.

Study 4

As promoting language and literacy skills might be key to attenuating the educational disparities found in Luxembourg, Study 4 focuses on listening comprehension and early literacy skills in first grade. Multiple predictors for these domains are examined across different home language groups (RI 5), including both voluntary preschool attendance (RI 2) and aspects of the home learning environment (RI 4). More specifically, Study 4 explores how home language groups differ in their exposure to different languages across contexts and in their exposure to media at home. Additionally, associations of preschool attendance, exposure to the language of instruction, and exposure to various media types with the two achievement

outcomes are analyzed. Central to the study was the examination of differences between home language groups, which were categorized based on their use of the language of instruction at home. Study 4 utilized linear regression and subgroup analyses on a full-population sample of $N = 5{,}929$ first graders in 2023. To deal with missing data and a nested data structure, multiple imputation and cluster-robust standard errors were used. Key background characteristics, i.e. SES, age, and gender, were included as control variables.

5 Study 1

Frühkindliche Bildung und Betreuung in Luxemburg: Wer nimmt die Angebote wahr und welche Effekte hat der Besuch auf frühe Schulleistung?

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Based on results of the Policy Report *Early childhood education and care in Luxembourg. Attendance and associations with early learning performance* (Hornung et al., 2023)

5.1 Einleitung

Seit Jahren weisen nationale und internationale Studien auf gravierende Leistungslücken zwischen verschiedenen Schüler:innengruppen in Grund- und weiterführenden Schulen in Luxemburg hin (z. B. MENFP/SCRIPT, 2000). Die Unterschiede in den Schlüsselkompetenzen sind bereits im Zyklus 2 zu erkennen und werden mit steigender Klassenstufe größer (LUCET, 2023). Auch international lassen sich immer wieder solche Leistungsunterschiede zwischen Schüler:innengruppen mit unterschiedlichem familiärem Hintergrund (sozioökonomisch, sprachlich und migrantisch) finden (z. B. Stanat & Christensen, 2006). In der diversen luxemburgischen Schülerschaft, in der 43,5 % der Schüler:innen eine andere Nationalität als die luxemburgische haben und 68,4 % der Schüler:innen nicht Luxemburgisch zuhause sprechen (MENJE & SCRIPT, 2024), betreffen die Effekte des sozioökonomischen Status sowie des Migrations- und Sprachhintergrunds eine besonders große Gruppe. Weiterhin verstärken die hohen sprachlichen Anforderungen im luxemburgischen Schulsystem die Leistungsunterschiede. Im vorschulischen Bereich *(Précoce* und Zyklus 1) ist Luxemburgisch Unterrichtssprache und seit 2017 soll zusätzlich Französisch gefördert werden. Französisch wird ab Zyklus 2 regulär unterrichtet, wobei die Alphabetisierung im Zyklus 2 in Deutsch stattfindet. Deutsch ist zudem offiziell Unterrichtssprache, aber auch Luxemburgisch wird häufig als Unterrichtssprache beobachtet (Fehlen, 2007). Wie neue Daten unterstreichen (Hornung et al., 2023), können nicht alle Kinder ihre Kenntnisse vom Luxemburgischen ins Deutsche übertragen und starten so oft mit erheblichen Sprachproblemen in ihre schulische Laufbahn (Hornung et al., 2021).

Es werden aktuell verschiedene Ansätze diskutiert, die diesen Leistungsunterschieden entgegenwirken könnten. Hierzu zählt unter anderem der frühe Besuch von Bildungseinrichtungen, der sich aufgrund des frühen Kontakts mit den Unterrichtssprachen positiv auf spätere Schulleistungen auswirken könnte. Ob dies in Luxemburg ebenfalls der Fall

ist, und wer in Luxemburg frühkindliche Bildung überhaupt besucht, wird in diesem Kapitel untersucht.

5.2 Frühkindliche Bildung und Betreuung in Luxemburg

Frühkindliche Bildung und Betreuung (FBBE) ist definiert als jegliches regulierte Angebot, das Kindern zwischen Geburt und Pflichtschulalter Bildung und Betreuung bietet (European Commission, 2022). In Luxemburg umfasst FBBE zum Beispiel *Crèches* (Krippen), die von Kindern zwischen 0 und 4 Jahren besucht werden können, eine freiwillige Vorschule, *Précoce,* die von Kindern im Alter zwischen drei und vier Jahren besucht wird, und den Zyklus 1, eine verpflichtende Vorschule für alle Kinder ab vier Jahren. Seit der FBBE-Reform im Jahr 2017, die mit den *Chèque Service Accueil* (CSA) eine Art Gutscheinsystem für 20 kostenlose Betreuungsstunden eingeführt hat, ist das FBBE-System Luxemburgs im internationalen Vergleich eins der bezahlbarsten in Relation zum elterlichen Einkommen (OECD, 2022b). Es ist ebenfalls charakterisiert durch einen starken privaten Sektor (Honig et al., 2015), was zu einer recht heterogenen Landschaft von FBBE-Angeboten im Hinblick auf Qualität und Ressourcen führt (OECD, 2022b). Die genannte FBBE-Reform 2017 ging mit einem frühen plurilingualen Bildungsprogramm *(Programme d'éducation plurilingue)* einher, welches festlegt, dass Sprachkenntnisse in Luxemburgisch und Französisch bei allen Kindern im Alter zwischen ein und sechs Jahren in non-formaler wie auch formaler FBBE zu fördern sind, aber auch die Familiensprachen valorisiert werden sollen. Deutsch wird im Rahmen dieses Bildungsprogramms nicht explizit hervorgehoben. Allerdings ist Deutsch Alphabetisierungssprache, so dass die Kinder nicht frühzeitig auf die Sprache vorbereitet werden, in der sie schreiben und lesen lernen—anders als in den Nachbarländern (Weth, 2018). Der Prozess der Alphabetisierung setzt jedoch möglichst gute Sprachkenntnisse in der Alphabetisierungssprache voraus (Tolchinsky & Berman, 2023). In der internationalen Forschung deutet ein Großteil der Literatur auf einen positiven Zusammenhang zwischen dem

Besuch von FBBE und kindlicher Entwicklung hin (z. B. DeAngelis et al., 2020), sowie auf das Potenzial von FBBE, Bildungsungleichheiten zu reduzieren (z. B. Heckman, 2006). Die Ergebnisse variieren jedoch stark mit den (Qualitäts-) Merkmalen der FBBE sowie den Merkmalen der Kinder und ihrer Familien (Bustamante et al., 2022). Im Folgenden werden die Ergebnisse der ersten systematischen, quantitativen Studie zu FBBE in Luxemburg aufgeführt, in der wir anhand eines großen Datensatzes über sechs Jahrgangskohorten von 2015 bis 2021 untersuchen, 1.) wer in Luxemburg welche Art von FBBE besucht und 2.) wie der Besuch von FBBE im Vergleich zu dem familiären Hintergrund mit Schulleistungen in Zyklus 2.1 zusammenhängt.

5.3 Empirische Befunde

Für diese Untersuchung haben wir Daten aus dem luxemburgischen Schulmonitoring-Programm *Épreuves Standardisées* (ÉpStan) aus den Jahren 2015 bis 2021 verwendet, die Schulleistungen der Schüler:innen im Zyklus 2.1 in den drei Lernbereichen—Luxemburgisch-Hörverstehen, Vorläuferfertigkeiten des Schriftspracherwerbs und Mathematik—beinhalten. Die Schulleistung wird in der ÉpStan-Metrik angegeben, einer Maßeinheit mit Mittelwert 500 und Standardabweichung 100. Die ÉpStan-Leistungstests erfassen dabei, wie gut die Lernziele des vergangenen Lernzyklus erreicht wurden. Ebenfalls vorhanden sind Daten aus Fragebögen von Schüler:innen und Erziehungsberechtigten mit Informationen zum sozioökonomischen Status (gemessen mit dem ISEI-Index), Migrationshintergrund und zu Familiensprachen sowie dem Besuch von FBBE[9]. Alle hier berichteten Ergebnisse stammen aus multivariaten Analysen, die den Einfluss mehrerer Einflussfaktoren auf den FBBE-Besuch und auf die Schulleistungen

[9] Wir haben basierend auf Angaben zur am meisten gesprochenen Sprache mit den Erziehungsberechtigten fünf verschiedene Familiensprachgruppen gebildet: monolingual Luxemburgisch und/oder Deutsch (im Folgenden Luxemburgisch*), monolingual Französisch, monolingual Portugiesisch, bilingual Luxemburgisch* und Französisch, bilingual Luxemburgisch* und Portugiesisch. Deutsch und Luxemburgisch sprechende Kinder wurden zusammengefasst, da sich beide Gruppen nicht signifikant in ihrem Luxemburgisch- und Deutsch-Hörverstehen unterschieden und nur 5 % der Kinder Deutsch als Familiensprache berichteten.

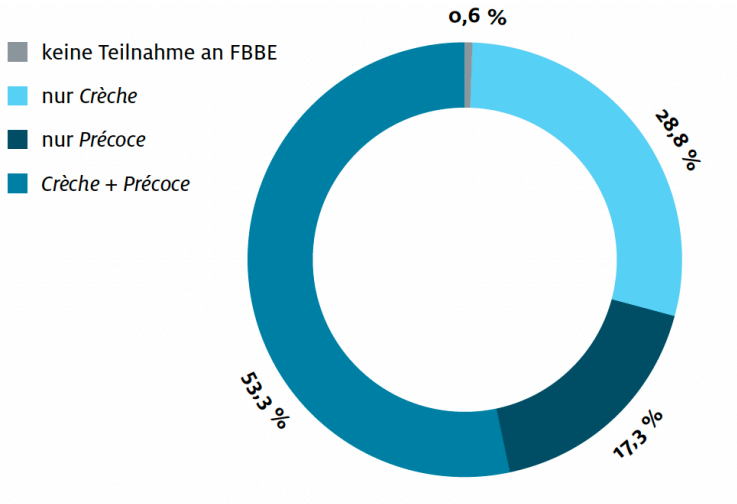
berücksichtigen. Dadurch kann der Einfluss eines bestimmten Merkmals, zum Beispiel des sozioökonomischen Status, auf den Besuch von FBBE unabhängig vom Einfluss anderer Merkmale, wie bspw. der Familiensprache, bestimmt werden.

5.4 Der Besuch von FBBE: Wer besucht welche Einrichtung in Luxemburg?

5.4.1 Einrichtungsarten

In der ÉpStan-Erhebung von 2021 berichteten 53 % aller teilnehmenden Erziehungsberechtigten, dass ihre Erstklässler in den Jahren zuvor sowohl eine *Crèche* als auch eine *Précoce* besucht hatten. Nur etwa ein Drittel (29 %) der Kinder hatte nur eine *Crèche* besucht und 17 % nur die *Précoce*. Ein verschwindend geringer Anteil der Erstklässler hat weder eine *Crèche* noch die *Précoce* besucht (unter 1 %, vgl. Abb. 4). Welche Kombination der FBBE-Einrichtungen besucht wurde, hing unter anderem vom familiären Hintergrund ab. So ist die Wahrscheinlichkeit, nur eine *Crèche* und keine *Précoce* zu besuchen, für Kinder, deren Familien erst vor Kurzem nach Luxemburg eingewandert sind, um 19 % höher als für Kinder ohne Migrationshintergrund. Für Familien mit steigendem sozioökonomischem Status steigt die Wahrscheinlichkeit, dass ihre Kinder sowohl eine *Crèche* als auch die *Précoce* besuchen, während die Wahrscheinlichkeit sinkt, dass sie nur die *Précoce* besuchen. Trotz dieser familiären Unterschiede beim Besuch von FBBE kann die Teilnahme an FBBE in Luxemburg als generell hoch beschrieben werden—was möglicherweise auch mit den geringen Kosten der FBBE und den hohen Lebenshaltungskosten in Luxemburg zusammenhängt, weshalb oft beide Erziehungsberechtigte berufstätig sind.

Figure 4. *Welche Arten von FBBE besuchten die Schülerinnen vor dem Zyklus 1?*

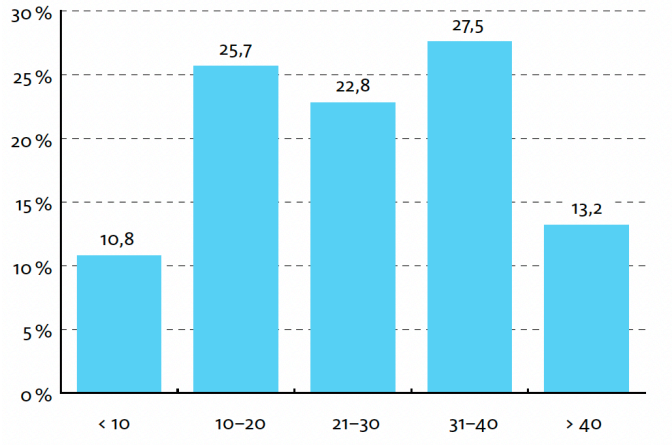


Note. 2021, n = 4.129, in %

5.4.2 Umfang des FBBE-Besuchs

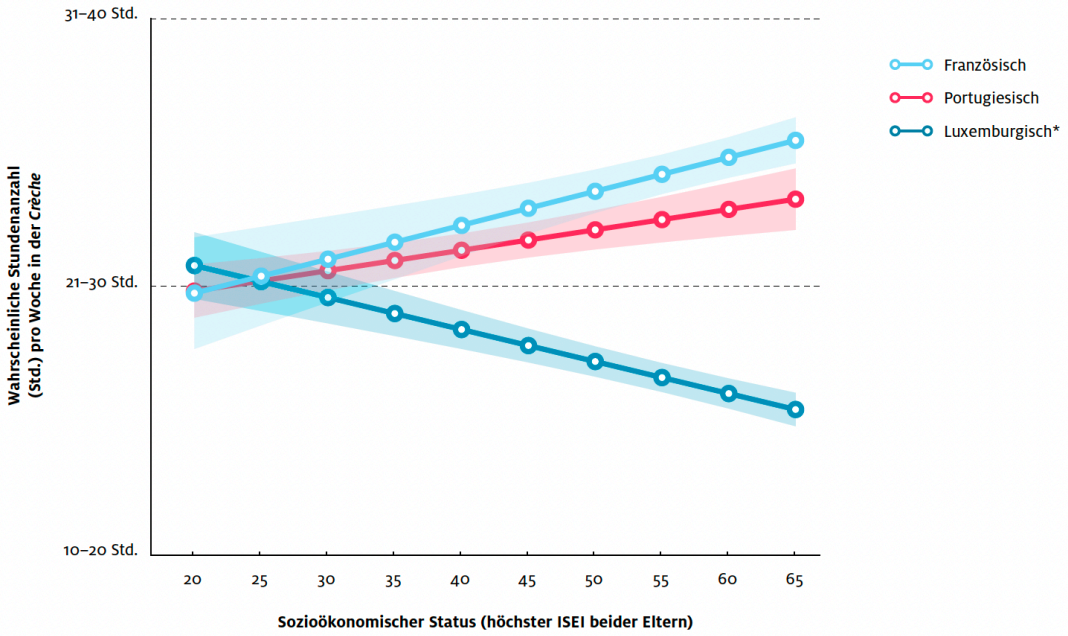
Die Gruppe der Kinder, die in eine *Crèche* gingen, haben die *Crèche* durchschnittlich 3 Jahre lang und überwiegend mit einer Intensität von 31 bis 40 Stunden pro Woche besucht, wie die Zahlen der Erstklässler von 2021 zeigen (vgl. Abb. 5). Der Umfang des *Crèche*-Besuchs steht auch mit dem familiären Hintergrund, insbesondere mit dem sozioökonomischen Status und der Familiensprache, in Zusammenhang. Während sich Familien mit niedrigem sozioökonomischen Status kaum in den Wochenstunden des *Crèche*-Besuchs ihrer Kinder voneinander unterscheiden, zeigen sich deutliche Unterschiede bei sozioökonomisch begünstigten portugiesisch- und französischsprachigen Familien gegenüber sozioökonomisch begünstigten luxemburgischsprachigen Familien: So besuchten beispielsweise Kinder aus sozioökonomisch begünstigten Familien, die zu Hause Portugiesisch oder Französisch sprechen, *Crèches* mehr Stunden pro Woche als Kinder aus sozioökonomisch begünstigten Familien, die zu Hause Luxemburgisch sprechen. Dieses Muster (vgl. Abb. 6) könnte auf ein komplexes Zusammenspiel aus den Arbeitsbedingungen (z. B. Flexibilität der Arbeitszeiten) und Betreuungsmöglichkeiten im Umfeld der Erziehungsberechtigten (z. B. Großeltern) zurückzuführen sein.

Figure 5. *Wie viele Stunden pro Woche besuchten Schülerinnen die Crèche vor dem Zyklus 1?*



Note. 2021, n = 2.265, in %

Figure 6. *Wie viele Stunden pro Woche besuchten Schülerinnen die Crèche nach Familiensprache?*



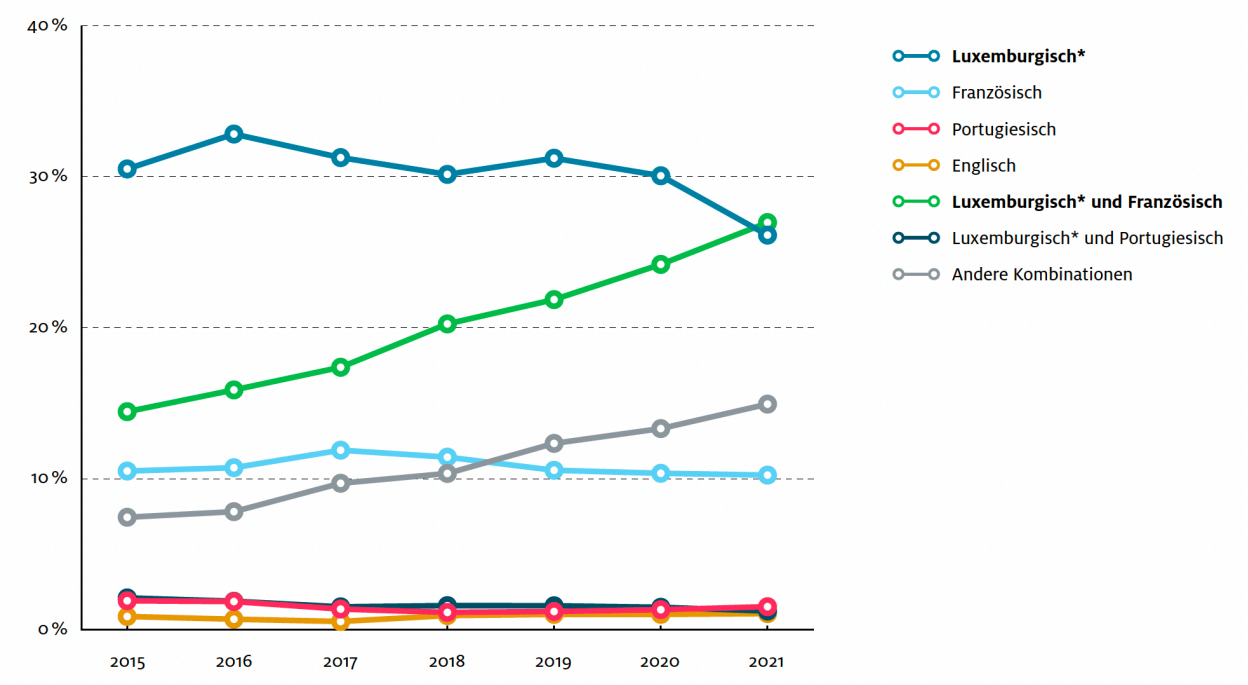
Note. 2019 bis 2021, *n* = 7.190. Schätzmethode: Lineare Regression. Der Graph zeigt die Predictive Margins mit einem 95 %-Konfidenzintervall. Kontrollvariablen: Sozioökonomischer Status, Migrationshintergrund, Familiensprache, Geschlecht, Jahr.

5.4.3 Häufigkeit der verschiedenen Crèche -Sprachen

In den Kohorten des Zyklus 2.1 (zwischen 2015 und 2021) ist Luxemburgisch die am häufigsten berichtete *Crèche*-Sprache, auch wenn die Häufigkeit der Nennung mit den Jahren

abnimmt. Immer häufiger wird eine Kombination aus Luxemburgisch* und Französisch (von 14 auf 26 %) oder weitere plurilinguale Sprach-Kombinationen als *Crèche*-Sprache (von 7 auf 15 %) berichtet (vgl. Abb. 7). Französisch wurde etwa von einem Zehntel der Erziehungsberechtigten als *Crèche*-Sprache angegeben. Über monolingual portugiesischsprachige, englischsprachige oder bilingual luxemburgisch-portugiesischsprachige *Crèches* wurde so gut wie nicht berichtet. Nur die letzten zwei Erhebungsjahre 2020 und 2021 umfassen dabei Schüler:innen, auf die sich die FBBE-Reform von 2017 (*Éducation plurilingue*) ausgewirkt haben könnte. So kann angenommen werden, dass der Anstieg der Kombination Luxemburgisch* und Französisch in den nächsten Erhebungsjahren noch deutlicher sichtbar sein wird. Insgesamt scheint Luxemburgisch in FBBE für die Mehrheit der Kinder eine dominante Rolle zu spielen.

Figure 7. *Crèche-Sprache(n) gemäß Elternangaben der Schüler:innen im Zyklus 2.1*



Note. 2015 bis 2021, n = 29.664, in %

5.5 Wie hängt der Besuch von FBBE im Vergleich zum familiären Hintergrund mit Schulleistungen im Zyklus 2.1 zusammen?

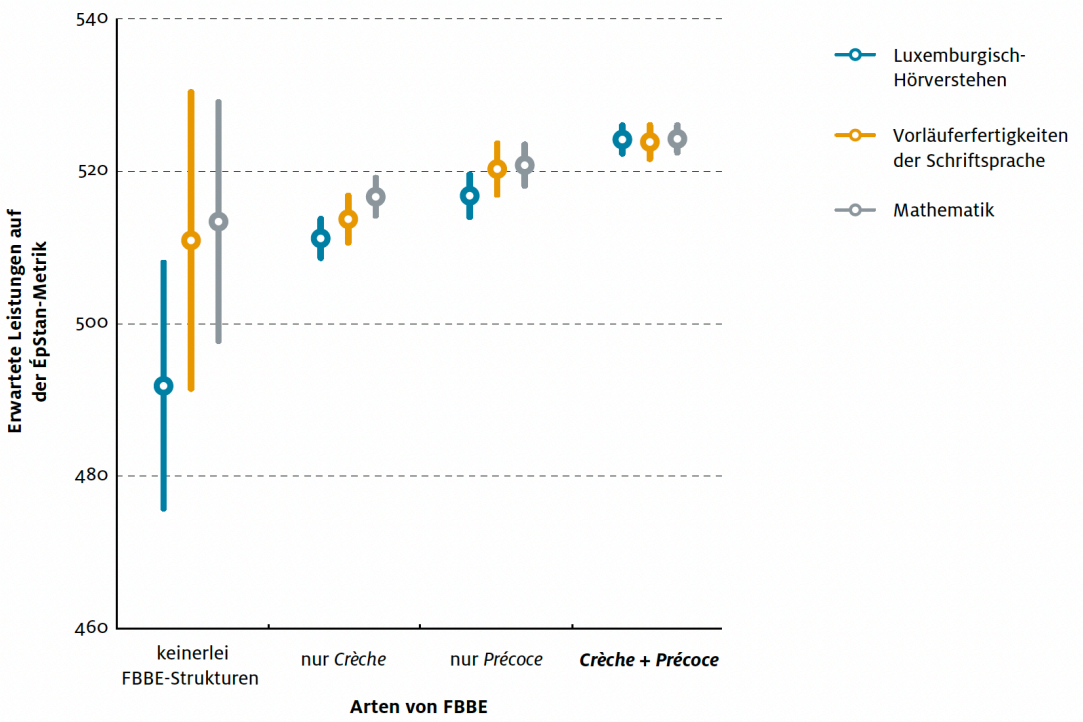
5.5.1 FBBE-Arten

Der Besuch von FBBE-Einrichtungen (*Crèche, Précoce*, Zyklus 1) steht in einem kleinen, aber positiven Zusammenhang mit Schulleistungen im Zyklus 2.1, unabhängig vom familiären Hintergrund (u. a. sozioökonomischer Status, Familiensprache) und anderen Merkmalen (Kindesalter, Erhebungsjahr oder *Allongement de Cycle*). Der kombinierte Besuch von *Crèche* und *Précoce* ist mit einer leicht höheren Schulleistung verbunden (8–13 Punkte auf der ÉpStan-Metrik je nach Lernbereich bei einer Streuung von ca. 2 Punkten[10]) im Vergleich zum alleinigen Besuch einer *Crèche*. Die Effekte sind jeweils am stärksten für Luxemburgisch-Hörverstehen (vgl. Abb. 8). Über die kleine Gruppe von Kindern, die weder *Crèche* noch *Précoce* besucht haben (weniger als 1 %), kann aufgrund der geringen Fallzahl keine gesicherte Aussage getroffen werden, was an den großen Konfidenzintervallen sichtbar ist.

Der Besuch von Zyklus 1 (C1.1 und C1.2) hängt ebenfalls positiv mit der Schulleistung zusammen. Pro Jahr im Zyklus 1 steigt die Leistung in allen drei Lernbereichen (9–16 Punkte auf der ÉpStan-Metrik pro Jahr je nach Lernbereich bei einer Streuung von ca. 2 Punkten).

[10] Hier berichten wir den Standardfehler der Koeffizientenschätzung als Streuung. Er gibt an, wie sehr der geschätzte Wert durchschnittlich vom wahren Wert abweicht.

Figure 8. *Arten von FBBE und Schulleistungen*



Note. 2015 bis 2021, n = 15.387. Schätzmethode: Multivariate Regression. Der Graph zeigt die Predictive Margins mit 95 %-Konfidenzintervall. Kontrollvariablen: FBBE, Zyklus 1, Sozioökonomischer Status, Migrationshintergrund, Familiensprache, Geschlecht, *Allongement*, Jahr.

5.5.2 Betreuungsumfang

Kinder, die eine *Crèche* länger besucht haben (d. h. mehrere Jahre), unterscheiden sich nicht signifikant in ihrer Schulleistung von denen, die eine *Crèche* für eine kürzere Dauer besucht haben. Allerdings gibt es bei der Intensität des *Crèche*-Besuchs (d. h. Anzahl der Stunden pro Woche) relevante Unterschiede zwischen bestimmten Gruppen von Kindern. Während Portugiesisch sprechende Kinder mit steigenden Wochenstunden in einer *Crèche* in allen Lernbereichen bessere Leistungen aufweisen, ist dies nicht der Fall für Luxemburgisch* sprechende Kinder. Da die Luxemburgisch* sprechende Gruppe durchschnittlich höhere Schulleistungen in beiden Sprachtests aufweist als andere Sprachgruppen, wird die Leistungsschere zwischen beiden Sprachgruppen bei höherer Wochenstundenanzahl reduziert. Portugiesisch sprechende Kinder profitieren schulisch also stärker von einer höheren

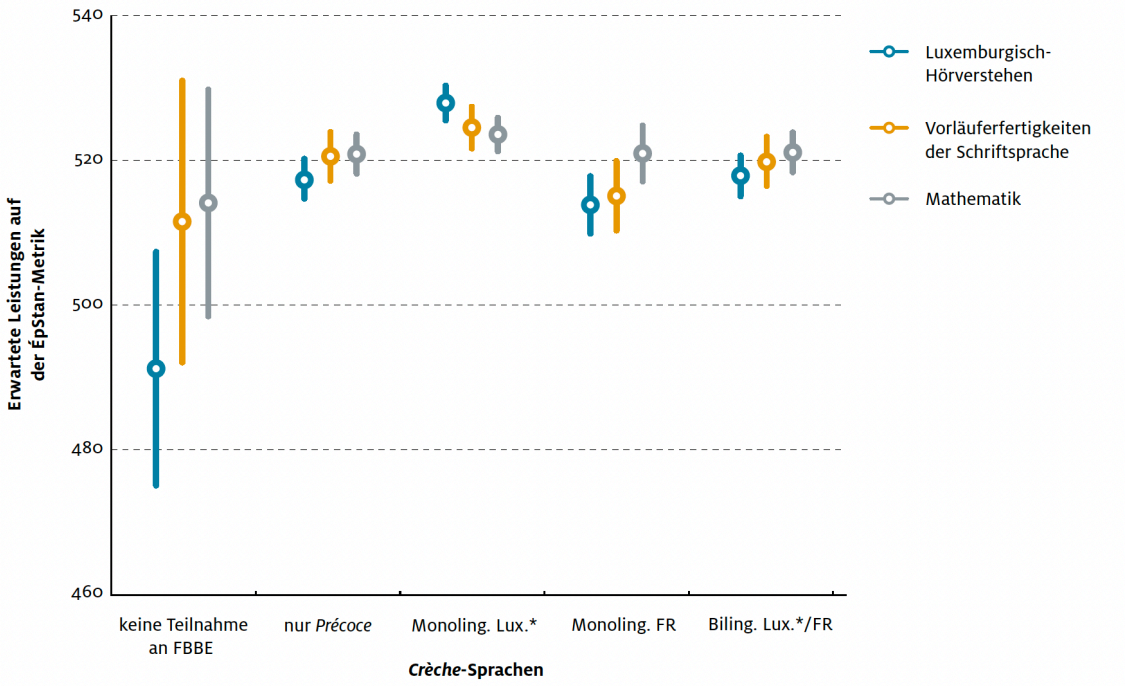
Wochenstundenanzahl in einer *Crèche* im Vergleich zu Luxemburgisch* sprechenden Kindern, die auch zuhause in engen Kontakt mit der Unterrichtssprache Luxemburgisch kommen.

5.5.3 Crèche-Sprachen und Leistung im Zyklus 2

Auch welche Sprachen in der *Crèche*[11] gesprochen wurden, stand mit der Schulleistung im Zyklus 2.1 in Zusammenhang. So war der Besuch einer *Crèche*, in der nur Luxemburgisch*[12] gesprochen wurde, im Vergleich zu fast allen anderen Sprachkombinationen mit höheren sprachlichen Schulleistungen verbunden (vgl. Abb. 9). Die größten Unterschiede nach *Crèche*-Sprache ließen sich dabei beim Luxemburgisch-Hörverstehen finden (Unterschied von 14 Punkten auf der ÉpStan-Metrik zwischen monolingual französischen und luxemburgischen* *Crèches*, Unterschied von 10 Punkten auf der ÉpStan-Metrik zwischen bilingual luxemburgisch*- französischen und luxemburgischen* *Crèches*, jeweils bei einer Streuung von ca. 2 Punkten). Unterschiede in den Vorläuferfertigkeiten für Schriftspracheerwerb zwischen den verschiedenen *Crèche*-Sprachen waren geringer ausgeprägt (Unterschiede von 9 bis 11 Punkten auf der ÉpStan-Metrik, bei einer Streuung von 2 bis 9 Punkten), während sich keine signifikanten Unterschiede zwischen den Mathematikleistungen in *Crèches* mit den am häufigsten vorkommenden *Crèche*-Sprachen finden lassen. Die Effekte der *Crèche*-Sprache auf die sprachlichen Kompetenzen deuten darauf hin, wie viel Zeit und sprachlicher Input für das Erlernen einer Sprache benötigt wird (Schulz & Grimm, 2019).

[11] Die Angaben zur *Crèche*-Sprache sind mit einer gewissen Messungenauigkeit behaftet, da sie von den Erziehungsberechtigten stammen.
[12] Ähnlich der Gruppierung bei den Familiensprachgruppen ist auch hier die kleine Anzahl der deutschsprachigen *Crèches* miteingeschlossen worden.

Figure 9. *Crèche-Sprachen und Schulleistungen*



Note. 2015 bis 2021, n = 15.387. Schätzmethode: Multivariate Regression. Der Graph zeigt die Predictive Margins mit 95 %-Konfidenzintervall. Kontrollvariablen: FBBE, *Crèche*-Sprachen, Zyklus 1, Sozioökonomischer Status, Migrationshintergrund, Familiensprache, Geschlecht, *Allongement*, Jahr.

5.5.4 Vergleich der Einflussgröße

In diesem Teil werden die Einflüsse des FBBE-Besuchs auf die Schulleistungen denen des familiären Hintergrunds und anderen Schülermerkmalen (wie Geschlecht und Alter) gegenübergestellt (vgl. Abb. 10, exemplarisch für Luxemburgisch-Hörverstehen). Im direkten Vergleich war der familiäre Hintergrund stärker mit der Schulleistung in allen drei Lernbereichen verbunden als der Besuch von FBBE[13]. Letzterer stand in einem kleinen, aber positiven Zusammenhang mit der Schulleistung. Im Hinblick auf den familiären Hintergrund ließen sich die bekannten Leistungsunterschiede in den drei Lernbereichen zwischen Kindern unterschiedlicher familiärer Herkunft bestätigen—mit Vorteil für einheimische, zuhause Luxemburgisch* sprechende Kinder aus sozioökonomisch begünstigten Familien. Alter und

[13] Hier wurden die standardisierten Regressionskoeffizienten (Beta-Koeffizienten) herangezogen.

Geschlecht hatten einen mittelgroßen Einfluss auf die Schulleistung. Ein weiterer Faktor neben FBBE ist *Allongement de Cycle*, die Verlängerung eines Lernzyklus um ein weiteres Jahr. *Allongement* ging mit niedrigerer Schulleistung in allen drei Bereichen einher (56–71 Punkte Unterschied auf der ÉpStan-Metrik je nach Lernbereich bei einer Streuung von 3 bis 4 Punkten) und sollte daher als oft genutzte pädagogische Maßnahme (OECD, 2017) in ihrer Wirksamkeit kritisch überdacht werden. Für die Lernbereiche Mathematik und Vorläuferfertigkeiten des Schriftspracherwerbs zeigen sich ähnliche Ergebnisse wie beim Luxemburgisch-Hörverstehen, mit Ausnahme des etwas geringeren Zusammenhangs von Familiensprache und Migrationshintergrund mit den beiden Lernbereichen.

Figure 10. *Einflussgröße verschiedener Faktoren auf Luxemburgisch-Hörverstehen*

Note. 2015–2021, n = 15.389. Schätzmethode: Multivariate Regression mit Haupteffekten der aufgeführten Variablen. Die Abbildung zeigt die relative Größe der standardisierten Regressionskoeffizienten.

5.6 Fazit und Ausblick

Die Ergebnisse dieses Kapitels beleuchten FBBE als eines der möglichen Instrumente zur Bewältigung der ausgeprägten Bildungsungerechtigkeiten in Luxemburg. Da der Besuch von FBBE in Luxemburg generell hoch ist, zeigt FBBE Potenzial, zukünftig eine wichtige Stellschraube zu sein, um die frühe sprachliche und mathematische Entwicklung zu fördern. Auswirkungen des FBBE-Besuchs auf sozioemotionale Faktoren (wie bspw. Wohlbefinden)

bei Kindern lagen außerhalb des Rahmens dieser Studie, sollten jedoch in folgenden Studien weitergehend untersucht werden. Da der Einfluss des FBBE-Besuchs auf die Schulleistungen zwar positiv, aber im Vergleich zum Einfluss des familiären Hintergrunds klein ist, empfehlen wir, die Effektivität der FBBE als pädagogisches Maß zu steigern, indem 1) die Qualität der FBBE stärker evaluiert und gefördert wird und 2) die Sprachcurricula und -praxen in der FBBE und dem anschließenden Schulsystem stärker aufeinander angepasst werden.

5.6.1 Qualität der FBBE stärker evaluieren und fördern

Eine hohe Qualität von FBBE-Angeboten scheint ein Schlüsselfaktor für positive Auswirkungen auf die kindliche Entwicklung zu sein (z. B. Burchinal et al., 2016). Auch die Heterogenität von FBBE-Systemen, die in Luxemburg groß ist, wurde in der Vergangenheit mit den Effektgrößen der FBBE in Verbindung gebracht (Driessen, 2004). Daher sollten strukturelle (z. B. Betreuungsschlüssel) und prozedurale (z. B. Merkmale der Interaktion zwischen Kind und Betreuenden) Qualitätsaspekte in Luxemburg systematisch evaluiert werden. Zusätzlich könnten mit mehr Monitoring-Daten zu verschiedenen Qualitätsaspekten und Sprachpraktiken in der FBBE wichtige Erkenntnisse über die Auswirkungen neuer Reformen im Bildungsbereich gewonnen werden. Dadurch soll FBBE aber keineswegs „verschult“ werden, sondern die kindliche Entwicklung im freien, explorierenden Spiel optimal unterstützt und gefördert werden.

5.6.2 Sprachcurricula aufeinander abstimmen

Beachtung sollte auch der Kontinuität der Sprachen in der FBBE und im weiteren Schulverlauf geschenkt werden. Ein passender Übergang ist derzeit aufgrund der flexibleren Sprachpolitik in der FBBE und der strengeren Sprachpraxis in der formalen Schulbildung nicht

gewährleistet[14]. Unter anderem ist es im aktuellen System nicht gegeben, dass Deutsch als Alphabetisierungssprache im Zyklus 2 in den verschiedenen FBBE-Einrichtungen besonders gefördert wird. Während unsere Befunde zeigen, dass sich der Besuch von FBBE besonders positiv auf luxemburgische Sprachkenntnisse auswirkt, konnte nicht gezeigt werden, dass für alle Sprachgruppen Luxemburgisch-Kenntnisse beim Erlernen der Alphabetisierungssprache Deutsch ausreichen (Kaufmann et al., 2023). Dabei sind Kenntnisse in der Alphabetisierungssprache wesentliche Voraussetzung von Lernen und Schulerfolg, besonders für die Kinder, die zuhause keine der Unterrichtssprachen sprechen. Aufgrund der Herausforderungen durch die sich verändernde und zunehmend diverse Schülerschaft ergibt sich so die dringende Empfehlung, die sprachlichen Anforderungen in den Lehrplänen und Richtlinien zu überarbeiten. Die mehrsprachige Bildung der FBBE sollte in der formalen Schulbildung weiterführend unterstützt werden, beispielsweise durch alternative Schulformen oder Alphabetisierungssprachen. Zusätzlich sollte aber auch Deutsch bereits in der FBBE explizit gefördert werden, um eine solide Grundlage für die Kinder zu schaffen, die auf Deutsch alphabetisiert werden.

Details und weiterführende Informationen zu dieser Arbeit finden sich in Hornung et al. (2023).

[14] Während non-formale Bereiche der FBBE besonders offen gegenüber den kulturellen und sprachlichen Bedürfnissen vieler Familien sind, passen sich luxemburgische, öffentliche Schulen nur langsam an die zunehmend multilinguale Schülerschaft an.

6 Study 2

Early childcare attendance, home language, and listening comprehension: Evidence from large-scale assessments in multilingual Luxembourg

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Abstract

Research Findings: Research indicates that early childcare is beneficial for children's language skills. Children from minority home language groups especially benefit from an early start. In this study, we investigated the association between early childcare attendance (ages 0 to 4 years) and listening comprehension in the language of instruction in multilingual Luxembourg. In particular, we analyzed whether this association was moderated by home language. Multilevel regression analyses on large-scale school monitoring data revealed that results depended on the home language group. Early childcare attendance, especially for a duration of 3 years, was positively associated with listening comprehension in the language of instruction among children who did not speak that language at home. Children who already spoke the language of instruction at home, monolingually or multilingually, did not benefit from childcare attendance or duration to the same extent. *Practice or Policy:* Our results extend the previous evidence on the potential of childcare to reduce disparities in the language of instruction, which is key for academic progress and success. These findings may guide stakeholders in monitoring and enhancing the quality of the language environment in early childcare settings, which could provide better starting points for children in linguistically diverse school populations.

6.1 Introduction

Early childhood is a critical period for children's cognitive, linguistic, physical, and socio-emotional development. Attending early childhood education and care (ECEC), especially high-quality ECEC settings, has been shown to have positive effects on various cognitive outcomes, including mathematics, reading, and language development (Camilli et al., 2010; DeAngelis et al., 2020; Lazzari & Vandenbroeck, 2012).

Language skills are key in nearly all situations across the lifespan (UNESCO, 2005). Especially skills in the language of school instruction and school-related literacy skills are important for further schooling – without them, children cannot process and connect to the school's input (Cummins, 2021; Schleppegrell, 2001). Proficiency in the language of instruction explains some of the achievement gaps between students of different home language backgrounds. For example, education reports often show that children who do not speak the language of instruction (or a similar language) at home perform worse on literacy tests than students who grow up with the language of instruction at home (UNESCO, 2016; Van Staden et al., 2016).

The threshold hypothesis (Cummins, 1979) proposes a benchmark level of language proficiency that bi- or multilingual students must attain to avoid difficulties in literacy acquisition. Accordingly, researchers have underlined that for these dual or multiple language learners, early contact with rich oral input in the language of instruction is essential to promote literacy skills (Byers-Heinlein & Lew-Williams, 2013; Gogolin & Neumann, 2009). Therefore, in contexts where children grow up multilingual, the onset of learning the language of instruction is crucial, and the critical period for successful childhood bilingualism is set before school age (Moser et al., 2008; Schulz & Grimm, 2019; cf. Tracy, 2008). Therefore, participation in ECEC may be particularly beneficial for multilingual children.

However, not all ECEC settings are the same. Generally, ECEC for older children (ages 3 to 5 years) is supported by more literature showing consistently positive outcomes (e.g., academic achievement, cognitive and language outcomes) than early childcare services for younger children (ages 0 to 3 years), which have been investigated less frequently and have yielded more mixed results (Melhuish et al., 2015). Characteristics of ECEC attendance, such as duration, have also been shown to impact its effects (Del Boca et al., 2022; W. Li et al., 2020).

In Luxembourg, a considerable portion of the student population grows up multilingual, and many children struggle with the language of instruction, which can cause them to lag behind their peers academically (Greisen et al., 2021; Hornung et al., 2021). ECEC in Luxembourg has already been recognized as key to facilitating language learning, which is why high-quality ECEC for 4- and 5-year-olds has been obligatory for all students since 1992. However, as it is recommended that children learn the language of instruction as early as possible (Tracy, 2009), we aimed to investigate not only attendance but also how time spent in voluntary early childcare before the age of four is related to language skills in the language of instruction for children of different linguistic backgrounds. More specifically, our study examines children's listening comprehension which, as a receptive language skill, is a prerequisite for academic success and predicts later reading comprehension skills (Hogan et al., 2014; Lervåg et al., 2018). Childcare duration in years represents one way to operationalize childcare dosage, alongside other indicators such as age of entry, session duration, and frequency of attendance (Wasik & Snell, 2019). In this study, the duration and age of entry are, however, intertwined. Long durations are only possible with early entry, but short durations are, though unlikely, also possible with an early entry into childcare. Thus, we include literature on both duration and age of entry in the following literature review.

General associations between early childcare and listening comprehension

In the early years, children's brains are developing fast and are thus especially malleable and sensitive to stimuli from the outside, such as experiences or environmental influences (Center on the Developing Child at Harvard University, 2016). Thus, attending childcare that offers safe and nurturing caregiving, engages children in playful activities, and provides rich, responsive language interactions can foster the acquisition of key language skills (Hoff, 2006b; Schoch et al., 2023). For example, daily opportunities to communicate with caregivers and peers in the language of instruction—combined with its stimulation through playful activities such as storytelling or nursery rhymes—can encourage and promote children's receptive and expressive language development (Incognito & Pinto, 2023).

Data from the Early Childhood Longitudinal Study in the U.S. (Loeb et al., 2007) show that children's language skills at age five, measured as a composite score including receptive language skills, improved when children had attended center care at age four or earlier instead of Head Start or other forms of non-parental care. Next to attendance itself, the retrospective study also examined the duration of attendance in years and found that more years in center care were positively correlated with short-term language outcomes. However, greater benefits were found when children started between ages 2 and 3 years, indicating a curvilinear relationship, with the best results observed at a moderate childcare duration.

This curvilinear trend is further supported by findings from the large-scale, longitudinal EPPSE/EPPNI study in the United Kingdom (Sylva et al., 2004). Each additional month of ECEC experience after age two was associated with better intellectual development, including both receptive and expressive language, at ages three and five. Thus, each month children started before the age of 3 years was associated with better scores; however, starting before the age of 2 years did not have any additional effect.

These curvilinear patterns might go back to the special vulnerability of children in the earliest years, as age-specific needs of pre-speech infants include a high responsiveness and reliability of caregivers (Fort et al., 2016), which may be hard to provide in an often short-staffed ECEC sector (Meisch & Hahn, 2025).

However, this does not mean positive childcare effects for the youngest children are not possible: Benefits of an earlier entry into center care also emerged in a study by Yazejian and colleagues (2015), who evaluated the effects of a targeted ECEC program (Educare) for under-6-year-olds of low-income families in the U.S. Receptive language abilities measured by the Peabody Picture Vocabulary Test (PPTV-4) between ages 3 and 5 years were higher when children entered care centers at a younger age or attended for more years. However, the effects of entry age and duration of attendance were confounded in this study. To disentangle these effects, Soliday Hong et al. (2023) compared the receptive language skills of children who started this program between ages 1.5 to 3 years with those of children who started later, between ages 3 to 4 years. They found that children who started center care as toddlers had better receptive skills (at age 3 to 4 years) compared to their peers who started later, even with a longer duration of attendance. This indicates it is indeed the entry age that drives this positive effect.

This conclusion is further supported by a meta-analysis by Li et al. (2020) who find that specialized ECEC programs for disadvantaged children in the U.S. between 1960 and the early 2000s that started in infancy had larger effect sizes than those that only started in the preschool years. Conversely, longer programs had smaller average effect sizes than shorter programs that took fewer years. This suggests an alternative explanation for the curvilinear patterns observed in childcare duration effects. If an early start is not inherently detrimental, a longer duration may indicate that children have already "max[ed] out" (Wasik & Snell, 2019, p. 35) the benefits of a particular childcare service—especially if it lacks an age-appropriate curriculum or fails

to provide further stimulating and developmentally challenging experiences. In such cases, children might benefit more from transitioning to a different ECEC environment that better aligns with their evolving needs (W. Li et al., 2020; Wasik & Snell, 2019).

Moderated effects

Similar to studies showing greater benefits for children from less advantaged families (e.g., low socioeconomic status, Davies et al., 2021; or immigration background; Felfe & Lalive, 2014), stronger associations between childcare attendance and duration and school-related listening comprehension can be expected for students who speak other languages than the language of instruction at home. These children may not only benefit from having an early start and additional time with the language of instruction through their childcare attendance but may also particularly profit from a varied and rich language environment in childcare settings. This is especially relevant if their parents lack the resources to provide a similarly stimulating linguistic experience in the language of instruction at home (McCabe et al., 2013). Interaction quality in ECEC has fittingly proven particularly relevant for the majority language development of multilingual students (Willard et al., 2021).

Moderated effects were indeed found for targeted ECEC programs for low-income students in the U.S., such as Educare. More years in the program, as well as starting at toddler age (ages 1.5 to 3 years) rather than at preschool age (ages 3 to 4 years), was found to be more strongly associated with higher receptive language skills for dual language learners than for single language learners (Soliday Hong et al., 2023; Yazejian et al., 2015).

This pattern is further supported by studies on universal ECEC (ages 0 to 5 years) in Germany (Kohl et al., 2019). Here, an early entry age benefited all students' receptive language skills in the language of instruction, measured between ages 2 and 6 years. Moreover, stronger effects were found for dual language learners with low exposure to the language of instruction at home compared to both single language learners and dual language learners who also spoke

the language of instruction at home. Thus, the group with the lowest language scores benefited the most from starting earlier, which helped to narrow the gap between the language groups.

Country Setting

The present study is situated in the multilingual context of Luxembourg, which features a heterogeneous, highly attended, and financially accessible ECEC system (Bollig et al., 2016; Honig, 2015; OECD, 2022b). Early childcare is provided in universal childcare centers (*crèches*) for children from birth to the age of 4 years. Attendance rates are high, as children under 3 years are more than twice as likely to attend early childcare than the OECD average (OECD, 2022b). For example, 63% of children under age three in Luxembourg attended early childcare in 2021 (Eurostat, 2024) with a modal attendance of 31 to 40 hours per week (Hornung et al., 2023). Childcare in Luxembourg is also highly affordable, as centers are subsidized by a voucher system that guarantees 20 free hours of childcare per week for all children. Further hours are subsidized depending on parental income. As the high demand for ECEC spots cannot be met by public services alone, the country also has a large private childcare sector, which includes both non-profit and commercial services (Wiltzius & Honig, 2015). Children below the age of four tend to be enrolled in commercial, for-profit settings: in 2023, nearly 50% of this age group attended a commercial setting, while 15 to 20% attended publicly financed settings (OECD, 2022b; Simoes Loureiro & Neumann, 2024). Next to these categories, ECEC in Luxembourg can also be separated into a non-formal (childcare centers or family care by parental assistance) and a formal ECEC sector which encompasses a voluntary preschool year from ages 3 to 4 years (*précoce*), and the two mandatory years of preschool from ages 4 to 6 years (*Cycle 1*) in public schools. ECEC in Luxembourg has thus been named a "double split system" (Bollig et al., 2016, p. 78), referring to both non-formal and formal, as well as both private and public services, resulting in a great heterogeneity in services and service quality (OECD, 2022b). This is also reflected in the diverse qualification requirements

for ECEC staff: Teachers in mandatory preschool hold a bachelor's degree in educational sciences. In voluntary preschool, one teacher with a bachelor's degree works in tandem with one caregiver with a vocational training background. Staff in childcare are required to have a vocational training, a diploma in education, art, music, language, or motor skills, or a basic training to develop pedagogical skills (Meisch, 2025a). Employees in early childcare are furthermore required to speak at least one or two[15] of the three official languages (Luxembourgish, German, French). Childcare centers also have some flexibility in the languages they offer. Languages range from the three mandatory official languages to others such as Portuguese and English, the most prominent languages besides the official languages. As a result, multiple languages are often spoken in childcare (MENJE, 2016), highlighting the linguistic diversity in Luxembourg's ECEC system.

Research on ECEC in Luxembourg has so far focused primarily on these multilingual practices (e.g., Kirsch & Aleksić, 2021). Nevertheless, recent results on the effectiveness of ECEC (ages 0 to 6 years) have indicated small yet positive associations between attendance in different ECEC settings and Luxembourgish listening comprehension (LLC) in first grade, as well as some selection effects showing children from families with lower socioeconomic status and a first-generation migration background attended childcare for a shorter duration than their peers. In addition, children of Portuguese-speaking families were more likely to attend childcare than children of monolingual Luxembourgish-speaking families and attended for a longer duration (Hornung et al., 2023). However, we still have a limited understanding of how early childcare in this multilingual context affects children from different language backgrounds—particularly the effect of whether or not their home language matches the language of instruction.

[15] In the publicly funded childcare sector, language proficiency in Luxembourgish and French has been required since the implementation of the plurilingual education programme in 2017. In the commercial childcare sector, proficiency in one official language is sufficient (De Moll et al., 2024).

Generally, Luxembourg's trilingual national school system is characterized by a high proportion of immigrants (United Nations, 2020) and a culturally diverse student population. A significant proportion of the student population (43%) does not have the Luxembourgish nationality, and an additional proportion (67%) does not speak Luxembourgish at home (MENJE & SCRIPT, 2022). As a result, many students grow up multilingually, exposed to various home languages, and are subsequently introduced to the three languages of instruction: Luxembourgish in preschool, German in primary school, and French in secondary school. This language policy across the curriculum places significant demands on both students and schools and leads at least partly to the notable disparities in academic achievement (Hornung et al., 2021; Sonnleitner et al., 2021).

As multilingualism plays an increasingly important role in our globalized world (Grosjean, 2018; Hong & Cheon, 2017) and "the kaleidoscope of diversities is here to stay" (Vandenbroeck, 2018, p. 411), findings from the diverse and multilingual context of Luxembourg may offer valuable insights to other countries.

6.2 Present Study

This study aims to address two research questions. First, (RQ1) what is the relationship between early childcare (ages 0-4 years) and listening comprehension in the language of instruction[16] in first grade? As outlined above, early childcare can offer an early rich language environment with responsive interactions, rich language, and playful activities that encourage and promote children's receptive and expressive language development (Center on the Developing Child at Harvard University, 2016; Incognito & Pinto, 2023). Therefore, we expect a positive association between both attendance and duration of early childcare and children's LLC. We expect associations between childcare and the language of instruction to be weaker

[16] While the early languages of instruction, Luxembourgish and German, are crucial for the academic trajectory and success, they do not serve as the dominant societal languages in the country as certain professions and administrative work are carried out in French. Thus, in this study, we refer to Luxembourgish and German as the languages of instruction rather than the majority languages.

than those in international findings, due to the multilingual nature of childcare. The high number of languages included in Luxembourgish childcare services beyond the instructional and home language may lead to less time-on-task with the measured language Luxembourgish (Godwin et al., 2021).

Due to the overlap of 1 year of childcare with the voluntary preschool year and high needs for quality and 1:1 care in the first year of life (Bowlby, 2007; Fort et al., 2016), attendance in the first year and the last year of childcare may not be associated with better child development. We therefore expect to observe the highest scores at a moderate duration of 2 years, after which additional years of childcare do not lead to higher scores, similarly to previously reported curvilinear trends of duration (Loeb et al., 2007; Sylva et al., 2004).

Second, (RQ2) how does the relationship between both early childcare attendance and duration and LLC differ for children with a different home language background?

Consistent with the findings of Kohl et al. (2019), we expect the association between early childcare and LLC to be moderated by children's home language background. Kohl et al. (2019) differentiated between dual-language-learner groups with high and low exposure to the language of instruction and only found a significant moderation effect of childcare in regard to the dual language group with low exposure to the language of instruction at home. Similarly, we examined three home language groups with varying levels of language of instruction use at home: 1) monolingual children who only speak the language of instruction at home (MonoLI), 2) multilingual children who speak the language of instruction and a second language at home (MultiLI), and 3) children who do not speak the language of instruction at home (NonLI). Greater benefits are expected for NonLI than MonoLI and MultiLI. For NonLI, attendance and longer duration in childcare may be crucial for developing skills in the language of instruction (Byers-Heinlein & Lew-Williams, 2013), as it provides an early exposure to and opportunity to speak the language of instruction. Besides the quantity of language input, childcare may also

offer a child-tailored, responsive, and rich language environment in which young children from diverse family backgrounds develop their language skills more easily (McCabe et al., 2013). We expect MultiLI students who use the language of instruction at home next to others to show no significant differences from the MonoLI group.

6.3 Methods

6.3.1 Procedure

The data used in this study were collected as part of the Luxembourg School Monitoring Programme Épreuves Standardisées (ÉpStan) in November 2021. The ÉpStan refer to a comprehensive large-scale assessment conducted each fall in first, third, fifth, seventh, and ninth grades, testing the attainment of curriculum objectives in the previous 2 years. In primary schools, the ÉpStan include pen-and-paper achievement tests and questionnaires for students and parents handed out by the class teacher, providing a standardized record of students' skills in key academic domains. These assessments thereby represent a valuable longitudinal data source within the Luxembourgish education system. All public schools in Luxembourg participate in the ÉpStan. The program has a proper legal basis and is approved by the national committee for data protection. Appropriate ethical standards were adhered to (APA, 2017). Prior to data collection, students and their parents or legal guardians are duly informed and have the possibility to opt-out. This study did not require ethical approval according to local legislation and institutional requirements, as it was a secondary data analysis of an existing dataset. To ensure students' privacy in accordance with the European Data Protection Regulation, the present analysis was conducted with an anonymized dataset.

6.3.2 Participants

While the 2021 cohort comprised 5,952 students, available data on all relevant variables was found for n = 3,813 first graders (49.9% female, 50.1% male) grouped in 410 classes in

166 primary schools in Luxembourg. Our sample comprised 134 students (5.7%) who were off track and had taken more than 2 years to complete learning cycle 1 (2 years of compulsory preschool), which explains the age range of 5 to 9 years (M = 6.4 years).

6.3.3 Measures

Luxembourgish listening comprehension (LLC)

The dependent variable for our analyses was LLC. The standardized test in ÉpStan assessed the oral understanding of vocabulary and syntax as well as the comprehension of texts on well-known topics such as, for instance, family, school, and animals. The test comprised 31 items assessing the comprehension of two conversations with three speakers each, two short stories, and one short factual text. The standardized test was administered in the classroom in November of the first grade after 2 months of formal schooling. Children's responses were collected in paper-and-pencil booklets. The test took 35 minutes, during which verbal instructions and test content were presented on a CD or an audio streaming platform. The resulting ÉpStan scores were Rasch-scaled to a mean of 500 and a standard deviation of 100. They were also anchored to the ÉpStan performances in the previous years. The test difficulty for the 31 items ranged between -1.85 and 1.39, with a mean of -0.27. Thus, the test was relatively easy. The items with a mean infit of 1, ranging between 0.86 and 1.19, fit well to the Rasch model. Further summary statistics on the IRT analysis are provided in the Appendix (see A1.1).

Early childcare

For the key variables, attendance and duration of early childcare, we used information from the parent questionnaire, which was provided in German, French, Portuguese, and English. Parents were asked how many years their children had attended a childcare center (early non-formal ECEC for ages 0 to 3 years) before they started compulsory preschool at age

four (response in full years). At age 3, childcare attendance can overlap with attendance in the voluntary preschool year. In the first block of our analyses, the childcare duration information was used to form a dichotomous variable indicating whether childcare had been attended. In the second block, we included duration in childcare in years as a metric variable and a quadratic term to account for a curvilinear relationship.

Home language group

Information on the moderating variable home language was collected through the student questionnaire, where first graders were asked to select the language they spoke most frequently with their mother and father, respectively. This questionnaire was administered by the teachers in Luxembourgish. Based on this information, they were classified into three possible language groups: MonoLI, i.e., they only spoke the language of instruction Luxembourgish (or German)[17] with their parents; MultiLI, if they spoke Luxembourgish (or German) and also at least one other language with their parents; and NonLI, if they spoke one or multiple other languages at home that did not include Luxembourgish (or German). As shown in Table 1, approximately 32% belonged to the MonoLI group, 16% were in the MultiLI group, and a slight majority of 52% spoke neither of these two languages at home (NonLI).

Age, gender, migration background, and socioeconomic status

We included age, gender, migration background, and socioeconomic status as controls since these variables can be related to both ECEC attendance and LLC. Age was calculated by subtracting the birth year, obtained from an administrative database, from the assessment year 2021. Gender was self-reported by the students. Migration background was assessed in the parent questionnaire by questions about the parents' and child's birth country. If the child and

[17] Luxembourgish originated as a German Moselle-Franconian dialect, so the two languages are linguistically close. Only a small group of children (8%) spoke German at home, and they scored similarly to the Luxembourgish group in the dependent variable. Therefore, Luxembourgish and German were grouped together in our home language groups.

at least one parent were born in Luxembourg, the child was categorized as native. Otherwise, they were first-generation (child and parents born outside the country) or second-generation (parents born outside the country) immigrants. The necessity of including both migration background and home language in the analyses is underlined by the high linguistic diversity within native families in Luxembourg, where 17% of native families do not speak the language of instruction at home (see Appendix A1.3). Socioeconomic status was operationalized by the highest parental occupational status as defined by the International Socio-Economic Index of Occupational Status (Ganzeboom, 2010). The resulting HISEI scores can range from 10 to 89, with high values indicating a high socioeconomic status. Information on sample composition

Table 1. *Descriptives*

Student Variables	**Definition**	**Mean**	***SD***	**Min**	**Max**	**Missing %**
Luxembourgish listening comprehension	Test score in Luxembourgish listening comprehension	514.55	103.87	103.21	858.09	7.91
Childcare attendance	Attendance in early non-formal childcare center for ages 0-4 years					
yes/no	Equals 1 if child attended childcare	0.82	0.39	0	1	17.79
in years	Number of years of childcare attendance	2.14	1.34	0	4	
in years^2	Number of years of childcare attendance squared	6.39	5.50	0	16	
Age	Difference between 2021 and birth year	6.39	.51	5	9	0.69
Gender	Equals 1 if child was male	.50	.50	0	1	13.07
Migration background	Migration background assessed on parent's and child's birth country					
Native	Equals 1 if child and both parents were born in Luxembourg	0.47	0.50	0	1	16.23
First generation	Equals 1 if child and both parents were born outside Luxembourg	0.15	0.35	0	1	
Second generation	Equals 1 if parents were born outside Luxembourg and child was born in Luxembourg	0.38	0.49	0	1	
Socioeconomic Status (HISEI)	Parent's highest occupational status defined by International Socio-Economic Index of Occupational Status (Ganzeboom, 2010)	51.50	15.83	16.25	69.90	17.05
Home language group	Groups based on the language that child speaks most frequently with parents					
MonoLI	Equals 1 if child speaks only Luxembourgish/German with parents	0.32	0.47	0	1	10.37
MultiLI	Equals 1 if child speaks Luxembourgish/German and at least one other language with parents	0.16	0.36	0	1	
NonLI	Equals 1 if child does not speak Luxembourgish/German with parents	0.52	0.50	0	1	

Note. Source = ÉpStan 2021, Missing % = percentage of the full sample missing information on this variable.

can be found in Table 1.

6.3.4 Analytic Approach

As students were clustered within schools and classes, we used three-level regressions to account for the lack of statistical independence and possibly skewed estimates and standard errors. In order to run estimations capable of three-level modeling, we omitted cases of missing data with a list-wise deletion approach (see Table 1 and Appendix A1.2 for more information on missing data). Supplemental analyses on missing data in our sample show a slight underrepresentation of children with lower Luxembourgish listening comprehension. They also indicate that potential comprehension problems with the language of the questionnaire may explain some of the missing data (see Appendix A1.2). To be sure that the listwise deletion did not bias our results, we conducted robustness analyses with imputed data and cluster robust *SE's* (see Appendix A1.2). The results remained consistent in both direction and significance.

The null model with random intercepts on class and school level allowed us to estimate the outcome variability at each of the three levels: students, classes, and schools (Hox et al., 2017). The ICC coefficient based on the variance components of the null model indicated that out of the total variance in LLC, 18% was located at the school level and 6% at the class level, justifying clustered regressions.

We report six multilevel models to estimate the association between early childcare attendance and duration with LLC.

The first three models, 1a, 1b, and 1c, present the estimations of LLC with early childcare attendance (yes/no). Model 1a introduced early childcare attendance as the predictor. Model 1b, the covariate model, added five family background characteristics: age, gender, migration background, socioeconomic status, and home language group.[18] We then added a

[18] We also tested exploratively one by one whether one of the coefficients of the full model had a random slope. All of these models produced warnings because of singular fit or non-convergence. Thus, we excluded random slopes in this study.

two-way interaction term of early childcare attendance with home language group in Model 1c, the moderation model. Model 1c examined whether the association between early childcare attendance and LLC varies across home language groups.

The last three models, 2a, 2b, and 2c, followed the same procedure. However, the key variables were now early childcare duration (number of years in childcare) and a quadratic term, allowing for a more detailed analysis of the association between early childcare and LLC. For Models 1c and 2c, subsequent post hoc tests for each home language group were conducted using pairwise comparisons of the estimated marginal means within and between home language groups. The results were noted as unstandardized coefficients and presented in margin plots for ease of interpretation. For all statistical tests, an alpha level of .05 was used. Alpha levels for the post-hoc tests were adjusted using the Tukey method. We report Cohen's *d* as an effect size for the post-hoc tests. Effect interpretation is based on Cohen (1988), where $|d|$ = .20 indicates small effects, $|d|$ = .50 medium effects, and $|d|$ = .80 large effects.

Histogram, Q-Q plot, and a positive kurtosis value (3.37) indicated that the dependent variable, LLC, might deviate from a normal distribution toward a leptokurtic distribution. Skewness and kurtosis values, however, were within some commonly suggested cutoff criteria (Byrne, 2011, p. 99). Requirements of multilevel linear regressions were then examined. Visual inspections and Levene's test confirmed homoscedasticity at the student level. However, Shapiro-Wilk tests indicated non-normality of residuals at the student level and non-normality of the random intercept. As visual inspections showed near-normality and Shapiro-Wilk tests tend towards significance in big samples such as ours, normality was assumed.

The analyses were performed using R version 4.3.1 (R Core Team, 2024a) with the packages apaTables (Stanley, 2023), emmeans (Lenth, 2023), ggeffects (Lüdecke, 2018), haven (Wickham et al., 2023), lmerTest (Kuznetsova et al., 2017), lme4 (Bates et al., 2015), mfp2 (Kipruto et al., 2025), performance (Lüdecke et al., 2021), rmarkdown (Allaire et al.,

2023), sjstats (Lüdecke, 2022), stats (R Core Team, 2024b), texreg (Leifeld, 2013), and tidyverse (Wickham et al., 2019). Prerequisite and additional analyses were performed with car (Fox & Weisberg, 2019), mice (Buuren & Groothuis-Oudshoorn, 2024), moments (Komsta & Novomestky, 2022), nlme (Pinheiro & Bates, 2023), psych (Revelle, 2023), rstatix (Kassambara, 2023b), and sjPlot (Lüdecke, 2023).

6.4 Results

Table 1 shows that the great majority of children (82%) attended early childcare with an average duration of 2 years. The maximum duration of childcare attendance was 4 years. In addition, Table 2 shows that there are descriptive differences between the language groups in terms of childcare attendance and duration. NonLI and MultiLI students were more likely to attend early childcare and attend for more years than the MonoLI group. More information can be found in the correlation table (see Table 3).

Table 2. *Sample characteristics and ECEC attendance by home language group*

Home lang-uage group	Listening compre-hension *M* (*SD*)	Child-care non-atten-ders %	Child-care duration of 1 year %	Child-care duration of 2 years %	Child-care duration of 3 years %	Child-care duration of 4 years %	Age *M* *(SD)*	Gender, male %	Native %	HISEI *M* (*SD*)
MonoLI	580.71 (88.92)	26.18	14.10	25.77	23.26	10.70	6.38 (.51)	52.35	93.27	54.75 (14.58)
MultiLI	511.91 (101.76)	15.15	12.12	20.88	32.32	19.53	6.35 (.50)	50.17	57.24	52.53 (15.32)
NonLI	474.22 (91.49)	13.85	11.59	23.83	30.03	20.71	6.40 (.50)	48.77	15.42	49.18 (16.33)

Note. Source = EpStan 2021. HISEI = Highest International Socio-Economic Index of Occupational Status (Ganzeboom, 2010).

The results of our estimations are presented in Table 4. When early childcare was included as the only predictor in the analysis, neither Model 1a (yes/no) nor Model 2a (number of years) showed significant associations with LLC. When family background information was added as covariates in Models 1b and 2b, the coefficients for early childcare turned significant and showed a positive association with LLC. In particular, children who attended early

Table 3. *Correlations with confidence intervals between all variables included in the models*

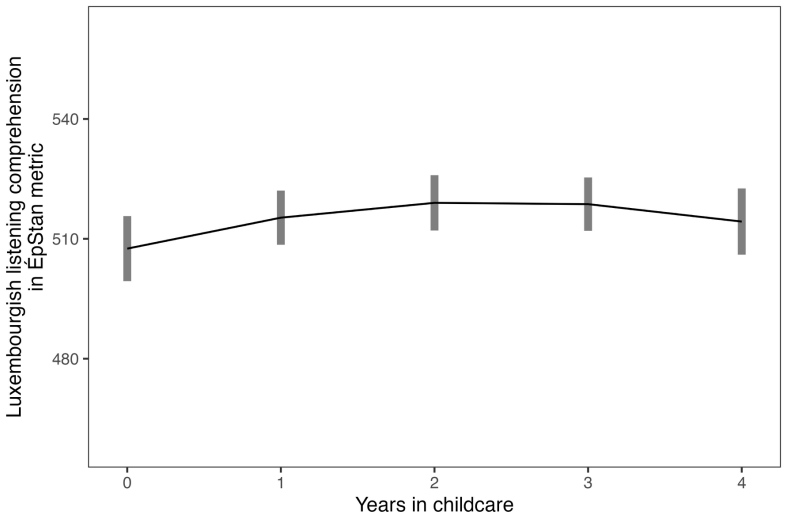
Variable	1	2	3	4	5	6	7	8	9
1. Listening comprehension									
2. Childcare attendance yes (reference: no)	.00 [-.03, .03]								
3. Childcare attendance in years	-.04* [-.07, -.01]	.75** [.74, .76]							
4. HL group MultiLI (reference: MonoLI)	-.44** [-.46, -.41]	.14** [.11, .18]	.18** [.15, .21]						
5. HL group NonLI (reference: MonoLI)	-.39** [-.42, -.37]	.11** [.08, .14]	.14** [.11, .17]	.72** [.70, .73]					
6. 1st generation migration background (reference: Natives)	-.40** [-.42, -.37]	.09** [.06, .12]	.11** [.08, .14]	.64** [.62, .66]	.66** [.64, .67]				
7. 2nd generation migration background (reference: natives)	-.28** [-.31, -.26]	.10** [.07, .13]	.16** [.13, .19]	.48** [.45, .50]	.46** [.43, .48]	.74** [.73, .75]			
8. Socioeconomic status (HISEI)	.31** [.28, .33]	.06** [.03, .10]	.01 [-.02, .04]	-.14** [-.17, -.11]	-.14** [-.17, -.11]	-.12** [-.15, -.09]	-.15** [-.18, -.12]		
9.Male gender (reference: female)	-.06** [-.09, -.03]	.01 [-.03, .04]	.00 [-.03, .04]	-.03 [-.06, .00]	-.03 [-.06, .00]	-.03 [-.06, .01]	-.03* [-.06, -.00]	-.00 [-.04, .03]	
10. Age	.00 [-.03, .04]	-.03 [-.06, .00]	-.01 [-.04, .02]	.00 [-.03, .03]	.02 [-.01, .05]	.02 [-.01, .05]	-.02 [-.06, .01]	-.09** [-.12, -.06]	.03* [.00, .06]

Note. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2014). ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

childcare were expected to score approximately 8 points higher in LLC (b = 8.08, p < .05) compared to those who did not. In the ÉpStan metric, this is a small, meaningful difference.

In addition, Model 2b, with significant coefficients for early childcare duration (b = 9.76, p < .01) and the quadratic term of early childcare duration (b = -2.02, p < .05), indicates that there was an inverted U-shaped relationship between early childcare duration and LLC. For clarity and ease of interpretation, Figure 11 illustrates that the children with the highest LLC scores were those with an average duration of early childcare of 2 and 3 years. For example, a native six-year-old girl with average socioeconomic status speaking the language of instruction at home reached an estimated 582 points after 2 years in childcare, which is 12 points higher than the score for 0 years in early childcare and 4 points higher than the score for 4 years.

Figure 11. *Margin plot of the nonlinear relationship between childcare duration and listening comprehension*



Note. Source = ÉpStan 2021. Based on Model 2b. Graph shows the association between childcare duration in years and listening comprehension. Error bars show 95% confidence intervals.

The control variables were all significant, showed the expected signs, and aligned with abundant research. Younger children, boys, children with a migration background, NonLI and MultiLI students, or students from socioeconomically disadvantaged families scored lower in

Table 4. *Overview of results and fit of all six models predicting Luxembourgish listening comprehension*

	Attendance (yes/no)			Attendance (in years)		
	Model 1a	**Model 1b**	**Model 1c**	**Model 2a**	**Model 2b**	**Model 2c**
(Intercept)	525.28 ***	446.35 ***	461.50 ***	519.17 ***	452.05 ***	457.50 ***
	(8.20)	(19.20)	(20.31)	(4.97)	(18.38)	(18.45)
Childcare attendance						
yes (reference no)	-3.64	8.08 *	-0.82			
	(3.94)	(3.51)	(5.30)			
in years				5.93	9.76 **	7.39 *
				(3.75)	(3.32)	(3.42)
in years²				-2.08 *	-2.02 *	-2.50 **
				(0.92)	(0.81)	(0.82)
Age		7.51 **	7.63 **		7.74 **	8.01 **
		(2.63)	(2.63)		(2.63)	(2.63)
Gender		-15.26 ***	-15.32 ***		-15.23 ***	-15.23 ***
(reference female)		(2.63)	(2.63)		(2.63)	(2.62)
Migration (reference Native)						
First generation		-33.74 ***	-33.23 ***		-33.55 ***	-32.36 ***
		(4.87)	(4.87)		(4.89)	(4.90)
Second generation		-25.43 ***	-25.46 ***		-25.40 ***	-25.35 ***
		(3.91)	(3.91)		(3.91)	(3.91)
Socioeconomic status		1.37 ***	1.36 ***		1.36 ***	1.35 ***
		(0.09)	(0.09)		(0.09)	(0.09)
Home language (reference MonoLI)						
MultiLI		-45.54 ***	-52.42 ***		-45.60 ***	-54.22 ***
		(4.38)	(20.06)		(4.39)	(7.93)
NonLI		-64.06 ***	-99.42 ***		-64.27 ***	-78.86 ***
		(4.23)	(14.21)		(4.25)	(6.34)
Interactions						
Attendance yes * MultiLI			4.22			
			(10.72)			
Attendance yes * NonLI			19.47 **			
			(7.49)			
Years * MultiLI						4.63
						(3.08)
Years * NonLI						7.05 **
						(2.27)
AIC	45,547.59	44,548.46	44,545.42	45,541.41	44,546.16	44,540.55
BIC	45,578.82	44,623.42	44,632.86	45,578.89	44,627.36	44,634.25
Log Likelihood	-22,768.80	-22,262.23	-22,258.71	-22,764.71	-22,260.08	-22,255.28
Class level variance	628.24	643.08	633.24	633.67	645.53	638.12
School level variance	1,846.34	797.45	791.30	1,800.58	787.98	777.09
Residual variance	8,029.95	6,194.19	6,187.18	8,015.92	6,187.64	6,176.20

Note. Unstandardized coefficients, *SE* reported in brackets, $N_{students}$ = 3,813, $N_{classes}$ = 410, $N_{schools}$= 166; ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

LLC compared to older children, girls, native students, MonoLI students, or children from socioeconomically advantaged families.

It's worth noting that the coefficients for early childcare only became significant after including background variables, suggesting a suppressor effect. Including family background strengthened the predictive value of early childcare attendance, especially since multilingual children tend to spend more time in care (see Table 3). Once background was accounted for, the unique role of childcare became clearer. Concerns about multicollinearity between family background and early childcare variables were mitigated after additional analyses showed variance inflation factors (VIF) below two for the predictors.

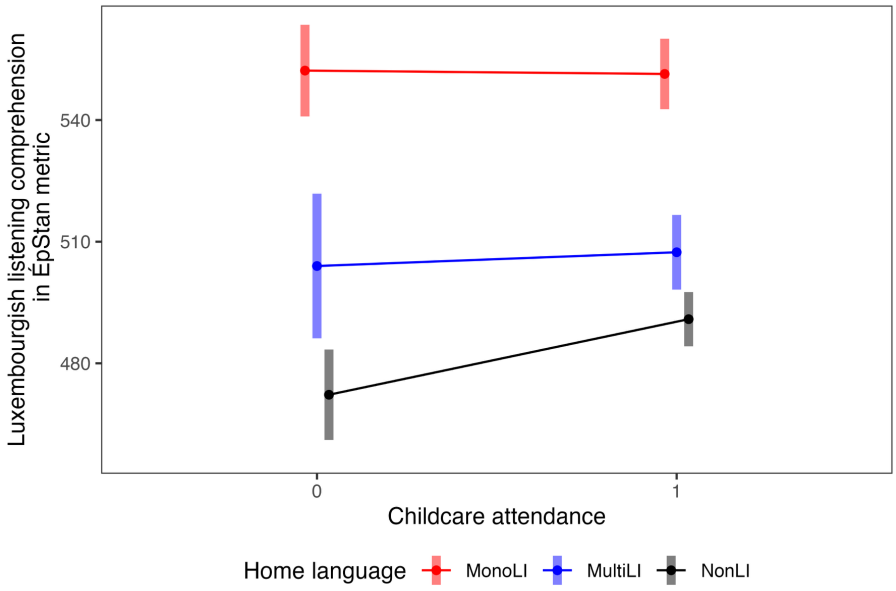
Exploring the interplay of early childcare and home language in more depth, Models 1c and 2c integrated the interaction of early childcare with home language. Both models revealed a significantly better model fit[19] based on deviance testing and AIC than the models without moderation terms and thus represent the final models from which our research questions are addressed, underlining the importance of considering interaction effects.

In Model 1c, the interaction term of home language group and early childcare attendance was significant, i.e., home language significantly moderated the relationship between childcare attendance and LLC (b = 19.47, p < .01). A closer look at the moderation shows that the previous positive general effect of early childcare on LLC was driven by one particular group: For NonLI students, attending childcare was associated with significantly higher LLC scores. Their estimated mean ÉpStan scores differed by 18.64 (p < .01) with a Cohen's d of -.24, indicating a small effect size (more information on post-hoc tests in A1.4 and A1.5 in the Appendix). However, for MonoLI and MultiLI students, childcare attendance did not result in significant differences in LLC scores (contrast = .83 to -3.39, p > .05). Marginal

[19] The BIC of the moderation models was slightly higher than for Models 1b and 2b as BIC penalizes model complexity more heavily (Field, 2009). Because both AIC and deviance testing point towards better fit, we choose Models c as the final models.

effects are plotted in Figure 12 and visualize how the gap in LLC was slightly reduced when NonLI children attended early childcare before the age of four.

Figure 12. *Margin plot of the two-way interaction between childcare attendance and home language group on listening comprehension*

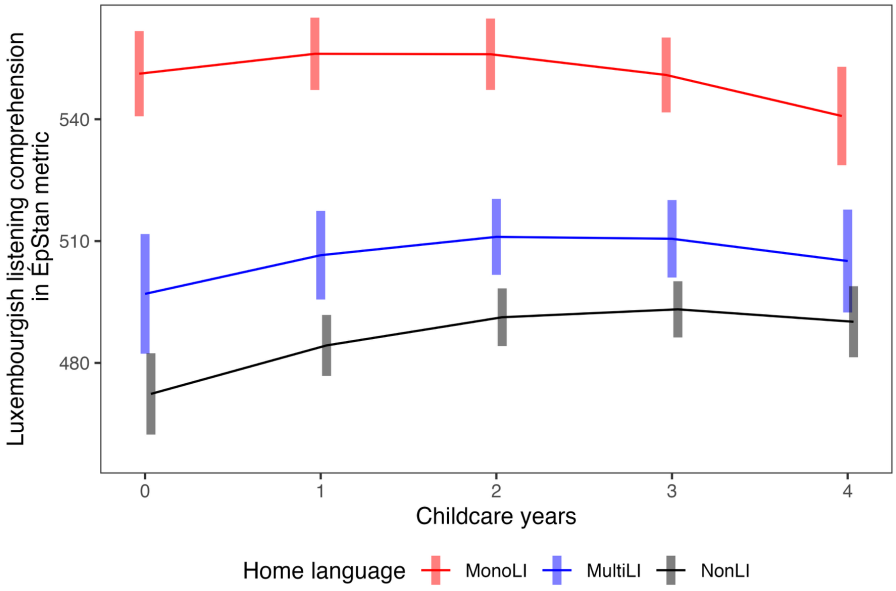


Note. Source = ÉpStan 2021. Based on Model 1c. Graph shows the association between childcare attendance and listening comprehension, separated by home language group. Error bars show 95% confidence intervals.

In Model 2c, home language also significantly moderated the relationship between childcare duration and LLC (b = 7.05, p < .01). Similar to Model 2b, both the linear and quadratic duration terms remained significant. Marginal effects are shown in Figure 13 for ease of interpretation. The plot descriptively shows that the highest LLC scores are found at a childcare duration of 1 to 2 years for MonoLI students, 2 to 3 years for MultiLI students, and 3 years for NonLI students. Post-hoc tests (see Table A1.5 in the Appendix) showed that LLC scores of NonLI children were significantly higher when children had attended childcare for 1 to 3 years in comparison to not attending or attending for 1 year (small effects with d = -.09 to -.27). For the MonoLI group, LLC scores were significantly higher when they had attended 2 to 3 years instead of 4 years of childcare (small effect with d = .13 to .19). The findings from Models 1c and 2c demonstrate that the association of early childcare and LLC significantly

differed for NonLI children compared to MonoLI children. The difference was evidenced by the significant interaction term and the distinct slopes for NonLI children compared to MonoLI children: In Figure 12, NonLI children's scores showed an increase while MonoLI children's scores remained the same. The pattern is further confirmed by significant post-hoc tests where the estimated difference of 80 points on the ÉpStan scale between MonoLI and NonLI groups *not* attending childcare is reduced to an estimated difference of 60.5 points between both groups *when* attending childcare (see Table A1.5 in the Appendix). In Figure 13, the NonLI children's curve revealed a peak at 3 years while the MonoLI children's curve peaked at 1 to 2 years. The two curves then converge, the longer the children attend childcare, as confirmed by significant post-hoc tests showing shrinking LLC score differences of 71.80 after 1 year, 64.80 after 2 years, 57.70 after 3 years, and 50.70 after 4 years of childcare attendance (see Table A1.5 in the Appendix).

Figure 13. *Margin plot of the two-way interaction between childcare duration and home language group on listening comprehension*



Note. Source = ÉpStan 2021. Based on Model 2c. Graph shows the (nonlinear) association between childcare duration in years and listening comprehension, separated by home language group. Error bars show 95% confidence intervals.

A notable similarity between MultiLI and NonLI children became apparent from Figure 13, where both curves for MultiLI and NonLI children showed a similar shape, being steeper

on the left-hand side until the third year of childcare attendance. This similarity did not emerge in the attendance model. Evidently, the duration of early childcare mattered with regard to LLC. However, while the coefficient and standard error sizes of the interaction terms supported the notion that both groups, MultiLI and NonLI, were similar compared to MonoLI (MultiLI: $b = 4.63$, $SE = 3.08$; NonLI: $b = 7.05$, $SE = 2.27$), the coefficient of MultiLI did not reach the significance level of $p < 0.05$, nor did LLC scores in the post-hoc tests differ significantly by duration of childcare for the MultiLI group (see Table A1.5 in the Appendix).

To sum up, the results for Models 1c and 2c indicate that the association of early childcare and LLC significantly differed for children who do not speak the language of instruction at home compared to the monolingual Luxembourgish/German children. Specifically, 1 to 3 years of childcare attendance seemed to be beneficial for these children over not attending childcare.

6.5 Discussion

6.5.1 Summary

This study aimed to investigate the relationship between the attendance and duration of early childcare and later listening comprehension in the language of instruction among children from different linguistic backgrounds with varying levels of using the language of instruction at home. Our multilevel analyses using large-scale monitoring data indicated that the relationships of LLC in first grade with previous childcare attendance and its duration depended on the children's home language group. Specifically, while there were positive associations between listening comprehension and childcare attendance and duration for children not speaking the language of instruction at home, this association was not observed in children speaking the language of instruction mono- or multilingually at home. This partially confirms our hypothesis for Research Question 1 and fully confirms the moderation hypothesis of

Research Question 2. As expected, we found an inverted U-shaped relationship between years of childcare and listening comprehension. We now discuss the results in more detail.

The positive effect of early childcare for children in the disadvantaged language group is consistent with most literature (DeAngelis et al., 2020; Loeb et al., 2007) and might be explained by several factors. Starting with the language of instruction early in life might be beneficial because language learning can happen more easily in the early years (Bruer, 2001; Friedmann & Rusou, 2015). In addition, an early start in ECEC often means the amount of time children spend engaged in literacy- and language-promoting activities increases. This provides them with consistent language models in the language of instruction and creates frequent opportunities for meaningful communication in that language (time-on-task hypothesis; see Godwin et al., 2021; Hoff, 2006b). Additionally, it might be that the multilingual education environment in childcare fits well for some children in this group. The inclusion of multiple home languages in early childcare settings may help children feel welcomed and valued, while also enabling them to build on their home language skills (Bialystok, 2018). For example, attendance in bilingual ECEC in other countries has not been shown to impede the development of proficiency in the majority language (Bialystok, 2018; Thieme et al., 2022). Additionally, the level of Luxembourgish used in childcare may be well adapted to their linguistic needs, supporting their acquisition of the language of instruction.

In contrast, children that already speak Luxembourgish at home do not further benefit from childcare attendance in their LLC. This raises the question of whether using the language of instruction at home may have already brought children's language skills to a level at which time in early childcare no longer yields significant additional gains. Additionally, the multilingual environment and the language level offered in childcare centers may be better tailored to the needs of children who do not speak Luxembourgish at home. As a result, Luxembourgish-speaking children might encounter less challenging language input in

childcare settings compared to what they experience at home within their families (Larson et al., 2020).

Duration analyses revealed a slight curvilinear trend of years in childcare, which in our study was correlated with but could not be directly translated into age of entry. Considering the possibility that the children in our sample attended the first optional preschool year (ages 3 to 4 years) in public schools instead of spending a fourth year in childcare, our results could reflect either the benefits of a later start, e.g. after the first year of life, or the advantages of an earlier transition out of childcare, such as beginning preschool at age 3. On one hand, a substantial body of literature cautions against starting non-parental care too early (Fort et al., 2016; Kottelenberg & Lehrer, 2014), particularly during the first year of life. During this period, children are not yet able to express their needs verbally (Im & Vanderweele, 2018) and require highly responsive caregiving, the consistent presence of a warm and sensitive caregiver, and a safe, secure environment (Bowlby, 2007). On the other hand, Li et al. (2020) and Soliday Hong et al. (2023) studies indicate that early starting ages were connected to greater positive childcare effects, while a longer duration was connected to smaller benefits of childcare. Therefore, our results may instead indicate that children have reached the maximum of benefits for Luxembourgish skills after 1 to 3 years in childcare (W. Li et al., 2020; Wasik & Snell, 2019) and may benefit more strongly from a transition to preschool (*précoce*) at age 3 and the experience of formal ECEC with explicit promotion of the Luxembourgish language and other school readiness skills.

More specifically, we found that the curvilinear trend with a descriptive peak at 1 to 3 years depended on the home language group. Thus, the "optimal" duration of childcare varied with the child's background. That is, children with the least usage of the language of instruction (those not speaking the language with their parents) benefited the most from a longer duration of 2 or 3 years. Children who speak the language of instruction, either mono- or multilingually

at home, had their peak in their LLC at marginally shorter durations of early childcare (around 2 years). These findings align with studies showing inverted U-shaped effects of childcare duration (Loeb et al., 2007) and build on Kohl et al.'s (2019) insight that children with the least exposure to the language of instruction at home are more likely to benefit from extended childcare. For these children, ECEC structures can offer a variety of learning and interaction opportunities, providing age-appropriate educational enrichment as well as language models and more communicative opportunities in the language of instruction than they may encounter at home (Council of the European Union, 2019; Kagitcibasi et al., 2009). For children that speak the language of instruction at home, more years in childcare were not associated with higher LLC. Instead, post-hoc tests for the MonoLI group showed lower LLC in the case of 4 years in childcare in comparison to 2 or 3 years in childcare (Table A1.5 in Appendix). As described above, this may be due to a need for a more challenging language level in ECEC which might be more accessible in the subsequent ECEC setting, i.e., early voluntary preschool at age three (W. Li et al., 2020).

Moreover, our results highlight that early childcare does not fully close the performance gap between children from different linguistic backgrounds (see Table A1.5 in the Appendix). Even after a long duration of early childcare attendance, children who speak the language of instruction at home still performed better. On the one hand, this may be due to the sizable head start of monolingual children and the importance of the home language in general (Paradis, 2011; Schulz & Grimm, 2019). On the other hand, children who do not speak the language of instruction at home might only experience the language of instruction in the ECEC context (Paradis, 2011) where the quality of the language environment may be constrained to directive speech rather than including complex language stimulation (Atkins-Burnett et al., 2011; Sawyer et al., 2018). Thus, with a more limited input, full proficiency in the language of instruction may not be achievable within a time frame comparable to that of monolingual

children. Alternatively, the high number of languages included in the multilingual Luxembourgish childcare services beyond the instructional and home language may make it challenging to provide each child with focused opportunities to engage with only their home and school languages and lead to less dedicated time-on-task (Godwin et al., 2021) with the assessed language Luxembourgish.

6.5.2 Limitations and Outlook

As we report in Table 2, early childcare attendance was associated with family background. For example, children who do not speak the language of instruction at home were more likely to attend early childcare and attend for more years than their peers. Not only attendance and duration of childcare, but also the intensity of childcare attendance in hours might vary across families and influence the effects of attending ECEC (Yazejian et al., 2015). We controlled for differences in the attendance patterns that stem from family background characteristics (i.e., home language, socioeconomic status, immigration background) by including these covariates in our models. However, the role of attendance intensity will need to be considered in future studies. Moreover, family background factors, such as migration and home language are intercorrelated. Research has indicated the potential for a complex interplay between these two variables, with implications for early achievement (Yazejian et al., 2015). Further research is required to disentangle their effects with regard to ECEC.

The languages spoken in early childcare and the quality of the language environment were not taken into account in this study. First, we turn to the aspect of which language is spoken: while in most countries, the language of instruction and therefore the lingua franca for children of different backgrounds is clear (Tracy, 2009), this is less straightforward in multilingual Luxembourg. Although, since the 2017 reform, childcare centers have been required to promote Luxembourgish and French (MENJE et al., 2021), many also offer additional languages, such as Portuguese or English, the most prominent languages in

Luxembourg after the three official ones. Additionally, caregivers and teachers are instructed to valorize the home languages of all children. Given this heterogeneity and flexibility in early childcare languages, the timing of language of instruction input may vary significantly across children and early childcare centers, which may in turn influence the effects on performance (Votruba-Drzal et al., 2015). Future research should therefore consider the languages spoken in ECEC including the communicative settings and pre-literacy activities and investigate the relationship of the language input in ECEC with individual language development and later academic performance.

Second, the quality of care and language stimulation have also been shown to play a critical role in supporting the long-term development of children's language skills (Sylva et al., 2011; van Huizen & Plantenga, 2018). In Luxembourg, systematic data on the quality of childcare and the language environment are currently missing as the ECEC landscape, providers, and regulations are quite heterogeneous and partly private. Therefore, we were not able to include quality of care and language environment in our study. However, policy efforts to ensure high quality in childcare have intensified in recent years, and the systematic collection of data on childcare centers is still in the process of being further developed (Meisch & Hahn, 2025; OECD, 2022b). We highly recommend this systematic evaluation and monitoring of ECEC quality in the field to identify measures that could further improve childcare quality in Luxembourg.

6.5.3 Implications

Based on the discovered beneficial childcare effects among children with little contact to the language of instruction at home, there is the question of whether raising attendance and the duration of early childcare in the multilingual group might help provide more equal starting conditions in Luxembourg. While disadvantaged groups are usually underrepresented in ECEC (Lazzari & Vandenbroeck, 2012), Luxembourg's attendance rates show a different picture (see

Table 2). A third of children speaking other languages than the language of instruction at home already attended childcare for 3 years, the "optimum" for that group. However, another fourth of this group attended early childcare for less than 2 years. Informing the respective parents about the potential language benefits of a slightly longer duration in early childcare could help to further boost the starting opportunities of multilingual children in first grade.

Secondly, while more research is needed to make sure that the discovered curvilinear duration effect indeed stems from benefits to ending childcare early and attending voluntary preschool (*précoce*) at age three, the majority of evidence points in this direction (Hornung et al., 2023; W. Li et al., 2020; Soliday Hong et al., 2023). Attendance in *précoce* is already quite high (76 % in 2021, see OEJQS, 2024a). However, it is less used by those that would benefit the most (Hornung et al., 2023). To ensure that all children, especially disadvantaged children, can access the *précoce* year, it is essential to further investigate the reasons for nonattendance and to prioritize the removal of known barriers, such as inflexible hours, by introducing full-day preschools.

Thirdly, our less beneficial findings for the monolingual home language group indicate that the language level in childcare may not be enriching or challenging enough for children already speaking the language at home to further foster their listening comprehension (Larson et al., 2020), while in other countries, children exhibited higher language skills when attending ECEC independent of their home language (Yazejian et al., 2015; Zambrana et al., 2016). Policy efforts to not only monitor but also improve the language environments in childcare to benefit all children are thus essential. One important step in this direction could be the promotion of higher qualification standards for early childcare staff. Currently, qualification requirements in Luxembourg's early childcare sector are relatively low compared to other OECD countries (OECD, 2022b). Additionally, it should be noted that the monolingual group

may profit from early childcare in other domains, such as school readiness skills, self-regulation, or social skills (Fukkink et al., 2024; Melo et al., 2022).

Lastly, compared to the effect sizes of the family background variables, the ECEC associations are considerably smaller and gaps are not closed (Hornung et al., 2023). A greater impact of early childcare on language of instruction skills might be possible with increased process quality in ECEC and enriched language environments (Ulferts et al., 2019; van Huizen & Plantenga, 2018). With challenging times ahead, a high-quality provision of ECEC for all children is crucial in Luxembourg and other countries. Fortunately, policy and monitoring efforts to ensure high quality in childcare have been gaining momentum with an increase in quality inspections since 2023. As recommended by OECD, broadening the available information on process quality by also introducing a systematic monitoring of interactions between staff and children could help "to identify gaps that need to be addressed and further guide policy development" (OECD, 2022b, p. 19).

6.6 Conclusion

Using large-scale data from Luxembourg's multilingual student population, this study indicates that the associations of early childcare attendance before the age of 4 years with first graders' listening comprehension in the language of instruction depended on the children's home language group. Multilingual students—those not speaking the language of instruction at home—were the only group to benefit significantly from attendance and more years in early childcare in a multilingual context. The moderated and curvilinear trend in childcare duration suggests that the optimal length of attendance varied across different home language groups. As receptive language skills, such as listening comprehension, provide the foundation for literacy acquisition and learning in all other school subjects, ECEC plays a vital role in potentially providing multilingual children with better opportunities to succeed when they start school.

6.7 Appendix

Appendix A1.1. *Psychometric information on the Luxembourgish listening test 2021*

The test items discriminated satisfactorily, with a mean RIT of 0.48 and a range between 0.34 and 0.60. Infit and RIT statistics were significant for all 31 items. The results of the DIF analysis show significant differences across gender and socioeconomic groups for any of the 31 items. Two out of the 31 items differed across migration subgroups (−0.93 and −0.59 for nonnatives), and three out of the 31 items differed across home language groups (0.83, 0.58, and 0.57 for German-speaking children).

Appendix A1.2. *Handling missings*

As described in the Methods section, complete information on all variables is available for 3,813 out of 5,952 students. To reduce concerns about estimation bias, we conducted analyses to investigate the missing data. First, we tested whether missingness in our predictor variables could predict Luxembourgish listening comprehension, LLC. While missing values in childcare attendance did not significantly predict LLC ($b = -8.32$, $p = .13$), missingness in family background variables was significantly associated with lower LLC ($p > .01$). This means that our sample underrepresented children with lower LLC. Second, we investigated whether missingness in each predictor variable could be predicted by values in the family background variables. Here, we find that missingness in the childcare variable did not depend on family background variables ($p > .05$); however, children with a first-generation migration background were more likely to have missing data on performance, gender, and socioeconomic background ($b = .74$ to $b = 1.06$, $p > .001$). This missingness may be due to comprehension problems in the language of the questionnaire or test.

To check whether our results stay robust when data is imputed, we employed multiple imputation by chained equations (MICE), assuming data were missing at random (MAR). Ten imputed datasets were generated using predictive mean matching for continuous

variables, logistic regression for binary variables, and polytomous logistic regression for categorical variables. All variables in the analyses besides binary childcare attendance were included in the imputation model. Binary childcare attendance was later derived from the imputed childcare duration variable. Analyses were performed on each dataset separately, and results were pooled using Rubin's rules. Imputation and analysis were performed in R using the mice package (Buuren & Groothuis-Oudshoorn, 2024). Regressions were performed using three-level regressions, including a school and class level, with the lmerTest package (Kuznetsova et al., 2017). Results show that findings stay robust in their direction and significance, whether data is imputed or not. On average, the effect sizes of focal contrasts in the robustness check changed between .055 to .001 *SD* to the main analyses, with a mean of .019 *SD*. A notable finding is the contrast between MonoLI childcare attendees and non-attenders, which now demonstrates a beneficial effect of childcare (imputed $d = -.017$, cp. to unimputed $d = .011$), although this effect remains negligible and non-significant. The effect size of the contrast between MultiLI childcare attenders and non-attenders was analogous to the non-imputed one (imputed $d = -.042$, cp. to unimputed $d = -.043$), while the effect size of the contrast between NonLI childcare attenders and non-attenders was marginally lower than the non-imputed one (imputed $d = -.193$, cp. to unimputed $d = -.237$). These small shifts in effect sizes suggest that the exclusion of cases may introduce a minor bias, potentially due to some of the systematic differences in missingness. For instance, children with lower LLC that are underrepresented in our data may be slightly more likely to benefit from childcare, which could explain the shift in the MonoLI contrast. However, the overall pattern of results remains stable and the changes negligible.

Table A1.3. *Number of observations by migration background and home language group*

Migration background	Home language group			
	MonoLI	MultiLI	NonLI	Total
Native	1,151	340	306	1,797
First generation	27	38	491	556
Second generation	56	216	1,188	1,460
Total	1,234	594	1,985	3,813

Appendix A1.4. *Post-hoc tests*

Post-hoc tests were conducted by getting pairwise contrasts from the emmeans package (Lenth, 2023) while considering the HL groups. *P*-values were adjusted with the Tukey method for comparing a family of several estimates. Degrees of freedom were estimated by the Kenward-Roger method. Results were averaged over the levels of gender and migration background. For model 1c, post-hoc tests show that LLC values of non-attenders and attenders of childcare within the MonoLI as well as within the MultiLI group did not differ significantly. Within the NonLI group, childcare attenders had significantly higher LLC scores than non-attenders, although the effect size was small ($d = –0.24$). Independent of childcare attendance, differences between home language groups were more pronounced: MonoLI had the highest and NonLI the lowest LLC scores, which post-hoc tests between language groups show. Cohen's *d* values in all but one group (Childcare yes: MultiLI – NonLI) between 0.40 and 1.02 suggest considerable effect sizes. For model 2c, post-hoc tests showed that LLC differences between different durations of attendance were not significant for the MultiLI group. For the MonoLI group, LLC scores were significantly lower when children had attended 4 years of childcare than when they had attended 2 or 3 years. The effect magnitude ($d = 0.13$ to $d = 0.19$) was low. For the NonLI group, LLC scores were higher when children had attended 1 to 4 years compared to non-attendance or 1 year of attendance; however, effect sizes ($d = −0.09$ to $d = −0.27$) were small. Again, MonoLI had the highest LLC scores at all durations of childcare, while NonLI showed the lowest scores ($p < .01$). Only the scores of the MultiLI and NonLI

group did not differ significantly at a childcare duration of 4 years (p = .052). The magnitude of the effect was considerable with Cohen's d between 0.65 and 1.00 for the comparison of MonoLI and NonLI.

Table A1.5. *Post-hoc tests and effect sizes*

Contrast	Estimate	*SE*	*p*	Cohen's *d*
Childcare attendance within home language groups				
MonoLI: no - yes	0.825	5.310	0.877	0.011
MultiLI: no - yes	-3.392	9.350	0.717	−0.043
NonLi: no - yes	-18.641	5.340	**0.001**	−0.237
Childcare attendance between home language groups				
Childcare no: MonoLI - MultiLI	48.200	9.900	**0.000**	0.613
Childcare no: MonoLI - NonLI	80.000	7.420	**0.000**	1.017
Childcare no: MultiLI - NonLI	31.800	10.100	**0.005**	0.404
Childcare yes: MonoLI - MultiLI	44.000	4.780	**0.000**	0.559
Childcare yes: MonoLI - NonLI	60.500	4.470	**0.000**	0.769
Childcare yes: MultiLI - NonLI	16.500	4.480	**0.001**	0.210
Childcare duration within home language groups				
MonoLI: 0 - 1 year	-4.894	2.750	0.385	-0.062
MonoLI: 0 - 2 years	-4.790	4.340	0.805	-0.061
MonoLI: 0 - 3 years	0.314	5.390	1.000	0.004
MonoLI: 0 - 4 years	10.416	7.040	0.577	0.133
MonoLI: 1 - 2 years	0.105	1.800	1.000	0.001
MonoLI: 1 - 3 years	5.208	3.520	0.577	0.066
MonoLI: 1 - 4 years	15.310	6.250	0.102	0.195
MonoLI: 2 - 3 years	5.103	2.080	0.102	0.065
MonoLI: 2 - 4 years	15.206	5.270	**0.032**	0.193
MonoLI: 3 - 4 years	10.102	3.300	**0.019**	0.129
MultiLI: 0 - 1 year	-9.520	3.540	0.056	-0.121
MultiLI: 0 - 2 years	-14.041	6.040	0.137	-0.179
MultiLI: 0 - 3 years	-13.562	7.980	0.434	-0.173
MultiLI: 0 - 4 years	-8.086	10.100	0.931	-0.103

Contrast		Estimate	*SE*	*p*	Cohen's *d*
	MultiLI: 1 - 2 years	-4.521	2.660	0.434	-0.058
	MultiLI: 1 - 3 years	-4.043	5.050	0.931	-0.051
	MultiLI: 1 - 4 years	1.434	7.970	1.000	0.018
	MultiLI: 2 - 3 years	0.478	2.660	1.000	0.006
	MultiLI: 2 - 4 years	5.955	6.030	0.861	0.076
	MultiLI: 3 - 4 years	5.477	3.530	0.530	0.070
	NonLI: 0 - 1 year	-11.941	2.930	**0.001**	-0.152
	NonLI: 0 - 2 years	-18.883	4.490	**0.000**	-0.240
	NonLI: 0 - 3 years	-20.826	5.080	**0.000**	-0.265
	NonLI: 0 - 4 years	-17.771	5.710	**0.016**	-0.226
	NonLI: 1 - 2 years	-6.942	1.690	**0.000**	-0.088
	NonLI: 1 - 3 years	-8.885	2.860	**0.016**	-0.113
	NonLI: 1 - 4 years	-5.830	4.810	0.745	-0.074
	NonLI: 2 - 3 years	-1.943	1.600	0.745	-0.025
	NonLI: 2 - 4 years	1.112	4.230	0.999	0.014
	NonLI: 3 - 4 years	3.056	2.780	0.807	0.039
Childcare duration between home language groups					
	0 years: MonoLI - MultiLI	54.200	7.940	**0.000**	0.690
	0 years: MonoLI - NonLI	78.900	6.350	**0.000**	1.003
	0 years: MultiLI - NonLI	24.600	7.910	**0.005**	0.314
	1 year: MonoLI - MultiLI	49.600	5.650	**0.000**	0.631
	1 year: MonoLI - NonLI	71.800	4.910	**0.000**	0.914
	1 year: MultiLI - NonLI	22.200	5.670	**0.000**	0.283
	2 years: MonoLI - MultiLI	45.000	4.440	**0.000**	0.572
	2 years: MonoLI - NonLI	64.800	4.260	**0.000**	0.824
	2 years: MultiLI - NonLI	19.800	4.300	**0.000**	0.252
	3 years: MonoLI - MultiLI	40.300	5.150	**0.000**	0.513
	3 years: MonoLI - NonLI	57.700	4.750	**0.000**	0.734
	3 years: MultiLI - NonLI	17.400	4.640	**0.001**	0.221
	4 years: MonoLI - MultiLI	35.700	7.240	**0.000**	0.455
	4 years: MonoLI - NonLI	50.700	6.120	**0.000**	0.645
	4 years: MultiLI - NonLI	15.000	6.430	0.052	0.190

Note. SE = Standard Error. *P*-values below .05 are in bold. Alpha levels were adjusted using the Tukey-method.

7 Study 3

Childcare attendance and its relation to academic performance and grade retention from grades 1 to 5: Results of a longitudinal study in Luxembourg

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Abstract

So far, long-term academic benefits of early childcare before the age of four have not been studied comprehensively. We investigated the association of childcare attendance with academic performance and grade retention from 2018 to 2023 and tested whether associations were stronger for disadvantaged children with lower socioeconomic status or not speaking the language of instruction at home. Using large-scale monitoring data of a nearly full cohort (n = 3,943–5,338) in multilingual Luxembourg in a secondary data analysis, we conducted path analyses on mathematics and reading from Grades 1 to 5, as well as logistic regression on grade retention. There were mostly no substantial associations between childcare attendance and duration with academic performance and grade retention across the cohort. However, for children not speaking the language of instruction at home, childcare attendance and duration were more beneficial concerning some academic outcomes (r = |.10–.18|, p < .05). Attending childcare, their probability of grade retention could be reduced from 25% to 19% while there was no significant decrease for their peers. Childcare duration had a curvilinear association with grade retention, indicating that after an initial decrease, a fourth year in childcare was associated with slightly increasing grade retention rates (β = .26, p < .05). Counterintuitively, children of higher SES benefited more from childcare attendance and duration in some outcomes (e.g., r = .14, p < .01). A comprehensive analysis of the equal accessibility of high-quality childcare provision in Luxembourg is key to reaping the potential benefits of childcare.

Keywords: Academic Achievement, Grade Retention, Early Childcare, Educational Inequalities, Multilingual Education Context

7.1 Introduction

Early childhood education and care (ECEC), defined as "any regulated arrangement that provides education and care to children from birth to compulsory primary school age" (European Commission, 2022), has been widely recognized as beneficial for cognitive development and various domains of academic achievement in the short and long-term (Bennett, 2012; Burger, 2010; Camilli et al., 2010; Ruhm & Waldfogel, 2012; Ulferts et al., 2019). As "starting behind often means staying behind" (OECD, 2020b, p. 28), attendance in ECEC structures such as childcare is also claimed to be an effective means of increasing educational equity.

This is crucially needed as family background factors such as socioeconomic status (SES) or home language (HL) are strongly associated with learning success (Abedi & Lord, 2001), academic achievement (Letourneau et al., 2011; Sandsør et al., 2021; Sirin, 2005; Van Staden et al., 2016), and school trajectories (Duran-Bonavila et al., 2024; Ferrão et al., 2017). These educational inequalities seem to have been exacerbated by the global crisis of COVID-19, along with its temporary school closures and emergency remote teaching. First data indicates achievement gaps have widened as disadvantaged students or students who were already underperforming often fell even further behind than they already had, amplifying an existing problem (Betthäuser et al., 2023; Borgonovi & Ferrara, 2022; Grewenig et al., 2021; Haelermans et al., 2022; Sonnemann & Goss, 2020).

This trend is especially worrying, given that Luxembourg is already struggling with comparatively large achievement gaps between advantaged and disadvantaged students (Hornung et al., 2021; Ottenbacher et al., 2024; Sonnleitner et al., 2021). It is thus highly prudent to investigate if and how ECEC attendance can have a long-term protective role on school careers and whether it especially protects disadvantaged populations from falling behind. As ECEC for 4-year-olds upwards has been obligatory in Luxembourg since 1992, we

are specifically interested in investigating the role that early childcare before the age of four plays.

Early Childcare and Academic Performance

Positive associations of early childcare attendance have been found with mathematical and reading skills in the short-term, i.e., in the performances of 5–6 year-olds in the United States (Loeb et al., 2007) as well as of 6–7-year-olds in Norway (Drange & Havnes, 2015) and in Luxembourg (Hornung et al., 2023). Concerning longitudinal outcomes, a study from Chile yields interesting results: It investigates the benefits of early public childcare programs (2–4 years) and reports better achievement in mathematics in Grades 4, 10, and 12 in comparison to non-attenders (Cortázar et al., 2020). However, for reading, they find significant results of childcare attendance in Grades 4 and 12, but not Grade 10 (Cortázar et al., 2020). Possibly, other factors such as enjoyment of reading might become a stronger predictor of later reading comprehension than early childcare attendance (Öngören & Volodina, 2024).

So far, there is only some short-term and mixed findings on the relationship between early childcare duration and academic performance. One study points towards longer duration of early childcare benefiting students' non-verbal cognitive performance at age 4 in the UK (Barnes & Melhuish, 2017), and early mathematics and reading at age 5 in the United States (Loeb et al., 2007). However, Loeb and colleagues also indicate that the best results are found with a medium duration (starting in childcare at the age of 2–3 years), suggesting a possible curvilinear relationship.

A strong and consistent finding of many reviews is that disadvantaged children (i.e., regarding their socioeconomic, ethnic, or language background) benefit more strongly from childcare and preschool attendance than their advantaged peers (Bennett, 2012; Lazzari & Vandenbroeck, 2013). Looking at early childcare studies only, a German study confirms early childcare attendance before the age of 3 had positive effects on school readiness only among

children of disadvantaged families with low SES or a migration background (Felfe & Lalive, 2014). While duration effects did not differ across different SES groups (Loeb et al., 2007), a longer duration and starting at toddler age (ages 1.5 to 3 years) in a targeted ECEC program was more positively associated with language skills for dual language learners than for single language learners (Soliday Hong et al., 2019; Yazejian et al., 2015). In addition to enhancing school readiness, ECEC also supports the development of mathematical and reading skills. In Canada, the performance gap in mathematics and reading between children of high and low SES could be closed when children with low SES attended childcare early from the age of 5 months on (Laurin et al., 2015). Across the border, in the United States, the beneficial effects of high-quality childcare attendance at age 3 seemed to erode by Grade 5, especially for socioeconomically disadvantaged students (Esping-Andersen et al., 2012). Thus, equity in mathematics and reading did not seem to increase with attendance. The same study, however, also looked at a Danish sample. In that sample, increased equity could be found in the reading scores at age 11 when high-quality childcare was attended at age 3, as disadvantaged children benefited especially. Taking both results together, this seems to indicate that the childcare system plays a big role: The more effective ECEC system in Denmark was characterized by high subsidies, universal usage, and homogeneity in standards and quality, with private childcare being almost non-existent. In the United States, on the other hand, their less effective ECEC system was described as “private and highly skewed” (Esping-Andersen et al., 2012, p. 8), in that family background was highly associated with the type and quality of care the child received. As the Luxembourgish ECEC system unites characteristics of both countries (highly attended and subsidized, but heterogeneous in quality and standards with many private childcare providers), it is especially interesting to see how our results compare to this study.

Early Childcare and Grade Retention

Childcare attendance can be beneficial not only for academic performance but by extension also for school trajectories. Grade retention, a practice to keep low-performing students at the same grade level for an additional year, is a measure that many countries use to give students a second chance to achieve the learning goals and keep classrooms at a homogenous performance level (OECD, 2020a). Across all OECD countries, 1.5% of students have been retained at primary and 2.2% at lower secondary level, compared to 3.6% at primary and 9.7% at lower secondary level in Luxembourg (OECD, 2024). The effectiveness of grade retention, however, has been called into question, with research indicating either an overall null effect on various variables (Goos et al., 2021; Ottenbacher et al., 2024; Wills, 2023) or even negative consequences, such as increased drop-out rates (Bowman, 2005; Goos et al., 2021; Jimerson, 2001; Tingle et al., 2012). Since retained students are disproportionately from disadvantaged groups (e.g., low SES or minority status) (Bonvin et al., 2008; OECD, 2020a), it is particularly important to investigate whether early childcare is associated with grade retention and if it can serve as a protective factor for disadvantaged students.

Beyond its findings on academic achievement, the above-mentioned Chilean study conducted by Cortázar et al. (2020) shows that children who attended early childcare (ages 2–4) were also less likely to repeat a grade between 4th and 12th grade compared to peers who did not attend childcare. Historical and more modern studies in the United States confirm this for ECEC before the age of 5—here, attendance was associated with an eight percentage point decrease in grade retention (McCoy et al., 2017).

Similar to how socioeconomic status and language background moderate the relationship between early childcare and academic achievement, there is also some evidence that socioeconomic background moderates the relationship between early childcare and grade retention. Cortázar and colleagues (2020) found that the childcare association with grade

retention was only positive for children of low and medium SES, whereas it did not have that association for the high SES group. A U.S. study corroborates this, indicating that ECEC programs for socioeconomically disadvantaged 2–4-year-olds are associated with reduced grade retention throughout the entire school period (Aos et al., 2004). To the best of our knowledge, no study has yet investigated how children's language background may moderate the relationship between early childcare attendance and grade retention. Similarly, there is scarce evidence on the association between childcare duration and grade retention.

7.2 Aims

The present study aims to investigate the impact of early childcare on academic performance and grade retention during elementary school in Luxembourg.

Despite extensive research on single aspects of the research aim, there is a lack of studies looking at the complex interplay between early childcare attendance before the age of four and academic performance and trajectories over an extended period of time. This study seeks to fill this gap by using large-scale, longitudinal monitoring data of a student cohort that attended elementary school in Luxembourg from 2018 to 2023. The cohort's rich test and questionnaire data allow us to investigate differential effects and moderators as well as different time points. Using data from Luxembourg gives insight into a diverse and multilingual country with early achievement gaps, while funding for the education sector is high (OECD, 2024).

Thus, the main objective of this paper was to determine whether early childcare was beneficial for academic performance and trajectories, and whether this relationship was stronger for disadvantaged groups. Specifically, our study addresses the following research questions:

1. How do early childcare attendance and duration before school entry predict academic performance in mathematics and reading in Grades 3 and 5?

2. How do early childcare attendance and duration before school entry relate to grade retention between 2018 and 2023?

3. How do family background variables (i.e., SES and HL) moderate these relationships?

Based on the presented literature, we hypothesize that early childcare attendance positively predicts mathematics and reading performance in Grades 3 and 5, while negatively predicting grade retention. Based on previous research, the strength of these associations should vary depending on SES and HL, with stronger relationships for disadvantaged students from lower SES families or not speaking the language of instruction at home (primary hypotheses). Secondly, we hypothesize that the same associations are found for mathematics and reading in Grade 1 (secondary hypothesis). Further secondary hypotheses are treated as model assumptions and reported in the methods section. The role of early childcare duration was investigated in an exploratory manner.

This research is significant because it addresses well-known educational disparities and explores early childcare as a measure that might alleviate the achievement gap. Thus, the study provides insights that can inform future policy to foster equity in education.

7.3 Method

7.3.1 General Information on Luxembourg's Educational Setting

Early childcare in Luxembourg, called "*crèche*", is a non-formal ECEC service for children aged 0 to 4. The service is offered by both public and private providers, thus creating a "split system" (Bollig et al., 2016; Honig et al., 2015). The proportion of public providers is quite small in comparison to private ones (ca. 15% in 2013 or 24% in 2025; Honig et al., 2015; Meisch, 2025b), and services often employ staff speaking multiple languages (De Moll et al., 2024). Attendance in early childcare is voluntary. Alternative modes of care in that age range

are family care at home, parental assistance ("Tageseltern"), or voluntary early preschool (a free-of-cost, one-year offer in public schools for children aged 3 to 4). However, attendance in early childcare is high (at approximately 80%) (Hornung et al., 2023; OECD, 2022b), and services are highly subsidized with at least 20 free hours per week per child, called Chèque-Service Acceuil (CSA) (Bousselin, 2021), amounting to nearly 10.000 € on average per child in childcare (Meisch, 2025). Quality assurance systems in Luxembourg are still in reform (OECD, 2022b). From 2016 to 2018, new regulations, laws, and guidelines for non-formal childcare were published, for example, childcare centers need to promote Luxembourgish and French to be eligible to participate in the CSA voucher scheme. After a transition period that ended in 2019 and a pause due to COVID-19, renewed efforts to control and monitor adherence to quality guidelines began in 2023 with increased control visits by regional officers (Meisch & Hahn, 2025).

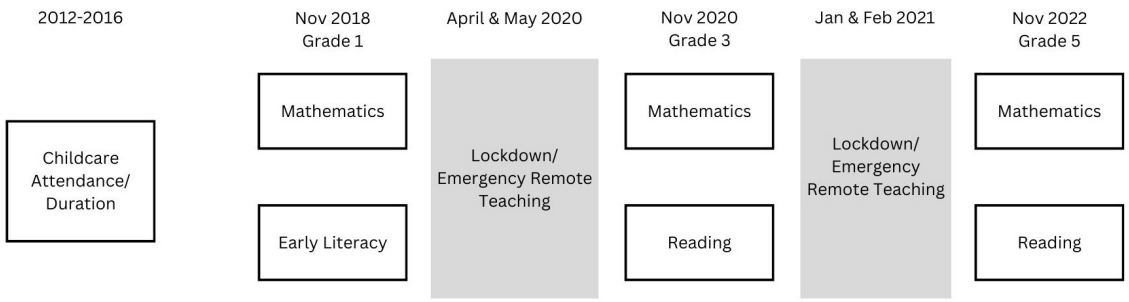
Educational settings in Luxembourg, including childcare, are characterized by their multilingual nature. While fostering Luxembourgish in voluntary early preschool (age 3–4) and mandatory preschool (age 4–6), formal schooling and literacy acquisition from Grade 1 on is conducted in German. French is orally introduced as a second language in Grade 1 and used as a language of instruction in later school years. Exceptions are the recently implemented international and European public schools offering literacy acquisition and formal schooling in German, French, or English (LUCET & SCRIPT, 2023).

7.3.2 Procedure

The data in this study stems from the Luxembourg school monitoring programme Épreuves Standardisées (ÉpStan). The monitoring is conducted at the beginning of every new learning cycle, every second school year (i.e., Grades 1, 3, 5, 7, and 9). The ÉpStan aim to measure the academic competencies of all students in key learning domains such as mathematics and languages in the public sector (196 schools) and produce valuable insights

for teachers, educators, and policymakers. Data collection for this study took place in November of the years 2018–2023 in grades 1, 3, and 5, respectively. Thus, the students experienced disrupted learning due to COVID-19 from spring 2020 to July 2021 (see Figure 14). Teachers received detailed explanations, instructions, and pen-and-paper testing booklets to assess students' academic performance in the classroom. Additionally, questionnaires were handed out to parents and students to collect information on students' family background and their academic motivation and well-being. All public schools in Luxembourg participated in the ÉpStan.

Figure 14. *Timepoints of lockdowns and measurements*



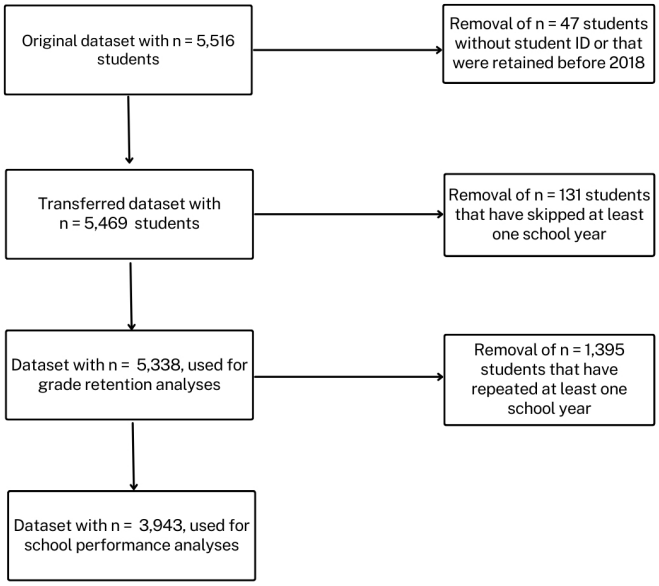
For the secondary data analysis of the ÉpStan dataset in our study, ethical approval was not required by the local laws. The ÉpStan themselves are based on Luxembourgish legislation and have the approval of the national committee for data protection. APA Ethical Principles (American Psychological Association, 2017) were adhered to. Analyses were performed with an anonymized dataset to comply with the European Data Protection Regulation.

7.3.3 Participants

For this study, we looked at longitudinal, observational data from the cohort attending Grade 1 in 2018 for the first time (N = 5,469). For the analyses on school performance, we excluded students who were held back at least one year between 2018 and 2022, and ended with n = 3,943 complete cases after multiple imputation. For the analyses on grade retention,

we took data from 2018 to 2023, only excluded cases that skipped a school year, and used a sample of *n* = 5,338 students here (see Figure 15).

Figure 15. *Flowchart of the sample size*



The sample for the path analysis is comprised of nearly equal numbers of girls and boys (50:50 split), of which 54% speak the language of instruction at home with at least one parent. The sample has a mean SES score of 51.19 on the HISEI scale (ranged 16.25–69.90) and a mean age of 6.4 years. Nearly three-quarters of students had attended early childcare before the age of four, on average for two years. More descriptive information can be found in Table 5 and in the Appendix (see A2.3).

7.3.4 Variables

For this study, we analyzed data on the outcome variables 1) mathematics, 2) reading, and 3) early literacy as well as 4) grade retention, predictor variables 5) early childcare attendance and 6) early childcare duration, and the control variables 6) SES and 7) HL.

Table 5. *Descriptive statistics for the path analysis dataset*

Variable	*n*	*M*	*SD*	min	max	skew	kurt
Mathematics (G5)	3,909	522.12	99.27	-0.68	974.14	0.06	0.76
Reading (G5)	3,814	515.98	98.67	233.37	788.37	0.24	-0.15
Mathematics (G3)	3,786	508.57	110.82	67.48	1,015.81	0.14	0.11
Reading (G3)	3,771	519.74	126.79	71.13	834.34	0.15	-0.25
Mathematics (G1)	3,939	529.83	81.85	121.29	863.92	0.27	0.66
Early literacy (G1)	3,857	532.94	110.33	171.58	839.07	0.30	0.10
Childcare (1 = attended)	3,919	0.74	0.44	0.00	1.00	-1.12	-0.75
Years in childcare	3,854	1.94	1.40	0.00	4.00	-0.08	-1.27
SES	3,906	51.19	16.00	16.25	69.90	-0.40	-1.14
HL (1 = speaks LI)	3,942	0.54	0.50	0.00	1.00	-0.16	-1.97
Gender (1= male)	3,943	0.50	0.50	0.00	1.00	0.00	-2.00
Age (G1)	3,942	6.36	0.50	5.00	8.00	0.70	-0.93

Note. n = available data before imputation; *M* = Mean; *SD* = Standard Deviation; skew = skewness; kurt = kurtosis; SES = socioeconomic status; HL = home language; LI = language of instruction.

Academic Performance

Academic performance was assessed in the learning domains mathematics (Grades 1–5), reading (Grade 3–5), and early literacy (Grade 1) in a highly standardized way. All standardized achievement tests are based on the national curriculum, developed by a multidisciplinary team of scientists and elementary school teachers, peer-reviewed, and thoroughly pre-tested by teachers in the field. For this study, we used performance scores based on WLE person parameter estimates from dichotomous Rasch models in all learning domains. The WLE reliabilities for Mathematics were .90, .92, and .90 in Grades 1, 3, and 5; .88 for Reading Comprehension in Grades 3 and 5, and .87 for Early Literacy in Grade 1. The R package TAM (Robitzsch et al., 2025) was used for Rasch scaling.

Each test was administered on a separate day within a time window of two weeks. In Grades 3 and 5, the tests were administered in German, and the students worked autonomously on their test booklet for 50 minutes. In Grade 1, both achievement tests were administered in

Luxembourgish by the class teacher, and the early literacy test was presented on a CD. The test duration was approximately 30 minutes per test. In all grades, the mathematics test included test items spread over two test booklets assessing the subskills in the domains of "numbers and operations", "space and shape", and "size and measurement". The mathematics test instructions were brief to minimize language and reading effects. For reading comprehension in Grades 3 and 5, continuous and discontinuous text forms were presented in German, assessing the subskills "identifying and applying information presented in a text" and "construing information and activating reading strategies/techniques". The early literacy test included test items assessing phonological awareness and visual discrimination skills, the understanding of the alphabetic principle as well as syllable and word reading and writing.

Grade Retention

This binary variable was constructed by checking whether students who attended Grade 1 in 2018 were on track or found in a lower class level than expected from 2019 to 2023. Students not on track were assigned a 1, students without grade retention were assigned a 0, and students who left the school system or skipped a grade were excluded from the analysis. We made no distinction between students being held back once or multiple times. In total, 21% of our sample was retained at least once. Of those 21%, most children were retained after Grade 2 (n = 678) or after Grade 4 (n = 370), as grade retention is most commonly employed only every other school grade in Luxembourg.

Early Childcare Attendance and Duration

Parents answered a questionnaire asking if their child attended early childcare before formal school entry (assessed from 2018 on) and how long their child had attended early childcare (assessed from 2019 on). In case of missing data in Grade 1, the information was taken from later parent questionnaires (completed between 2019 and 2023). In case of

inconsistent data across the collection years, earlier time points were prioritized. For our main analysis, we used early childcare as a dichotomous variable, while duration data in years was used for the exploratory analysis. Descriptive statistics split by childcare attendance can be found in Table 6.

Table 6. *Descriptive statistics for the path analysis dataset split by childcare attendance and duration*

		Student background		Family background		Early performance	
	n	Age *M* (*SD*)	Gender (% male)	HL (% speaking LI at home)	SES *M* (*SD*)	Mathematics G1 *M* (*SD*)	Early Literacy G1 *M* (*SD*)
full sample	3943	6.36 (0.50)	0.50	0.54	51.19 (16.00)	529.83 (81.85)	532.94 (110.33)
split by Attendance							
no attendance	1003	6.36 (0.51)	0.49	0.62	49.10 (16.51)	528.15 (81.35)	530.26 (111.96)
attendance	2916	6.36 (0.50)	0.50	0.51	51.90 (15.76)	530.97 (81.69)	534.32 (109.66)
split by Duration							
1 year	484	6.38 (0.51)	0.51	0.60	51.57 (16.50)	528.46 (80.56)	536.64 (114.33)
2 years	896	6.36 (0.50)	0.51	0.57	52.67 (15.64)	535.57 (84.98)	535.35 (112.33)
3 years	929	6.34 (0.48)	0.47	0.47	52.72 (15.46)	534.36 (81.80)	542.00 (109.16)
4 years	604	6.37 (0.49)	0.52	0.43	49.17 (15.78)	523.24 (79.24)	521.50 (103.82)

Note. Descriptives before imputation; *M* = Mean; *SD* = Standard Deviation; HL = home language; LI = language of instruction; SES = socioeconomic status.

Socioeconomic Status (SES)

SES was measured by the HISEI scale (highest parental occupation level). ISEI stands for International Socio-Economic Index of Occupational Status (Ganzeboom, 2010). Parents indicated the top-level ISCO (ILO, 2012) category corresponding to their occupation, with example occupations common in Luxembourg listed as a reference. Average ISEI values for these categories were computed from Luxembourgish data from the Programme for International Student Assessment (PISA), separately for mothers and fathers. High values indicate a high parental SES. We took data from later parent questionnaires (2019–2022), in

case of missing data in Grade 1. We prioritized earlier information if the information was inconsistent across years.

Home Language (HL)

HL is a dichotomous variable based on two items in the student questionnaire in Grade 1. In those items, students indicated the language they most often speak with each of their parents. The answers were recoded into either 0 if students did not speak one of the languages of instruction, Luxembourgish and German, with at least one of their parents, or 1 if they spoke Luxembourgish and/or German with at least one of their parents. Again, we took data from later parent questionnaires (2019–2022), in case of missing data in Grade 1. Earlier time points were prioritized if information was inconsistent across years.

7.3.5 Data Analyses

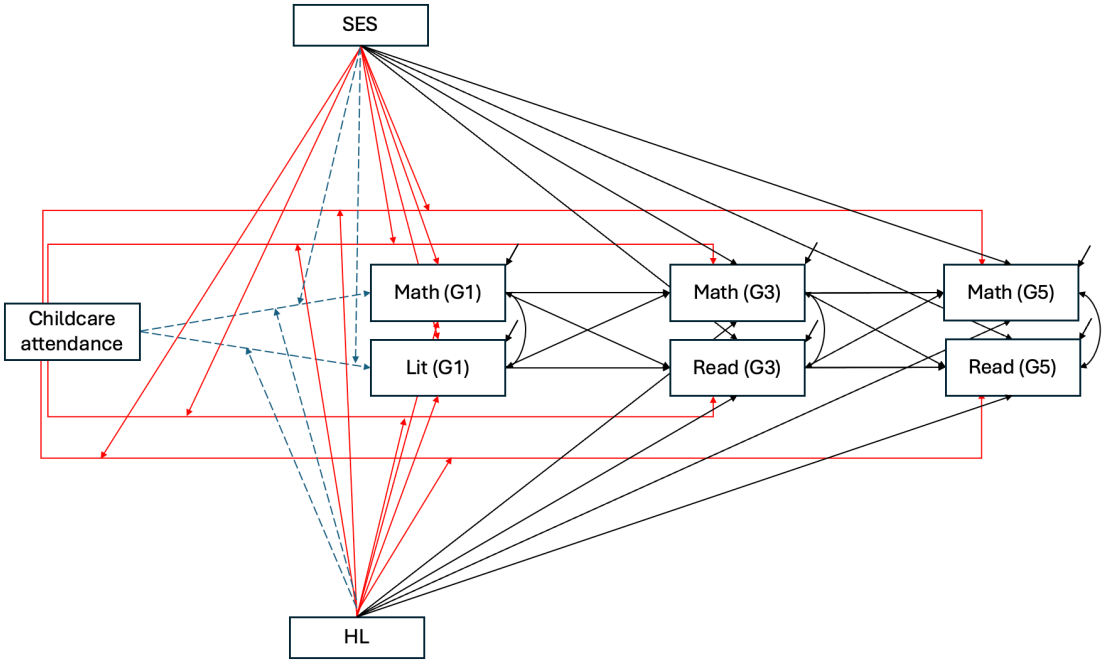
To deal with missing data (see Table 5, Appendix A2.1 and A2.2 on missingness and attrition), we used multiple imputation via the R package mixgb (Deng & Lumley, 2023). Mixgb uses XGBoost gradient trees, subsampling, and predictive mean matching to better capture interactions in an efficient and non-biased way (Deng & Lumley, 2024). We imputed two sets of ten datasets, one set for the path analysis sample and one set for the grade retention sample. Auxiliary variables used in the imputation were gender and birth year for both samples and academic performance in Grade 1 for the grade retention sample. Outliers were included in our data, as all values were plausible.

Two path analyses were conducted—one focusing on attendance and the other on duration—using the R package lavaan.mi (Jorgensen et al., 2024), which extends lavaan (Rosseel et al., 2024) to support multiple imputation. We assumed associations between family background characteristics (i.e., SES and HL) and academic performance in mathematics and reading at both time points (Grades 3 and 5). As prior knowledge is a key predictor of later

learning (Hattie, 2010), we included Grade 1 performance in mathematics and early literacy in our models. We also modeled autoregressive paths so that previous academic performance was assumed to predict performance at the next time point. Given the impact of language and reading skills on mathematics performance (Greisen et al., 2021; Paetsch et al., 2016), reading and early literacy performance of the previous time point are assumed to not only predict later reading performance but later mathematics performance as well. In addition to these preregistered model assumptions, we included the associations of previous mathematics performance with later reading performance to allow a full cross-lagged panel design and let each year's performances correlate with each other (see Document on Transparent Changes). We z-standardized the performance variables and SES to prevent excessively unequal variance sizes between our binary and continuous variables. To circumvent the normality assumption for our binary predictors, we treated the exogenous observed variables as fixed. For post-hoc analyses, we additionally estimated the path analyses without the moderation terms and the path analyses with a reverse-coded HL variable. The latter are not reported comprehensively and are only used to interpret differential findings for the opposite HL group in the text. The full design of the path model with childcare attendance is shown in Figure 16, and a selected part R model syntax can be found in the Appendix (see A2.4). As the full path model is complex, results will be portrayed in two separate figures to improve readability.

Analyses on grade retention were conducted with pooled logistic regression using the mice package (Buuren & Groothuis-Oudshoorn, 2024). We included SES and HL as control and moderation variables. Similarly to the path analyses, we calculate an attendance model and, exploratively, a duration model. For post-hoc tests, we used the package emmeans (Lenth, 2023) to estimate and contrast marginal means and slopes. We also added visualizations of moderation relationships when moderation terms reached significance.

Figure 16. *Path model design (attendance model)*



Note. Math = mathematics; Read = reading; SES = socioeconomic status; HL = home language; primary hypotheses in red (light grey), secondary in blue (dashed), and model assumptions in black (dark grey).

For all exploratory analyses with childcare duration, we also tested whether a quadratic trend would better describe the relationship, as suggested by previous findings (Kaufmann, Ottenbacher, et al., 2025; Loeb et al., 2007; Sylva et al., 2004). For the regression analysis on grade retention, models including the quadratic term had a slightly better model fit ($AIC_{quadratic}$ = 5,068 vs. AIC_{linear} = 5,071), while path analysis including the quadratic term performed slightly worse than those without ($AIC_{quadratic}$ = 51,186 vs. AIC_{linear} = 51,182). Thus, we report the path analyses without the quadratic term and the logistic regression with the quadratic term of childcare duration.

As classes and schools may change between grades, we were not able to include the nested data structure in our analyses. This may lead to slightly skewed estimates. Thus, we used the robust estimator "MLR" for the path analyses. Multicollinearity of predictors was not an issue in the grade retention analyses (see correlation tables in the Appendix, A2.5 and A2.6).

While the large sample size led to significant Shapiro-Wilk tests ($p < .001$), the normal distribution of the performance variables could be confirmed visually.

For all statistical tests, an alpha level of .05 was used. We report standardized coefficients and unstandardized coefficients to facilitate interpretation and ensure comparability.

Effect sizes were indicated by the standardized coefficients in the logistic regression and by the compound correlation in the path models, as calculated as a sum of compound paths based on Wright's Rules (Loehlin, 2004). Effects are interpreted based on Gignac and Szodorai's guidelines (2016), where $r = .10$ indicates small effects, $r = .30$ medium effects, and $r = .50$ large effects. We report $\chi 2$, CFI, RMSEA, SRMR, and AIC as model fit indices (Kline, 2016). The model fit was evaluated using the criteria established by Byrne (1994), with a good fit indicated by a CFI > 0.90, an RMSEA < 0.05, and an SRMR < 0.08. All path analysis models had very good model fit indicated by CFI and SRMR but did not reach good model fit with $\chi 2$ and RMSEA (>.1). As RMSEA tends to overestimate misfit in models with a small number of degrees of freedom such as ours (df = 4) and $\chi 2$ is highly sensitive to sample size (Bergh, 2015), we accepted the models solely based on CFI and SRMR (Kenny et al., 2015). Model fit, estimated covariances, and variances are reported in the Appendix (see Table A2.7).

In addition to the packages already mentioned, our analyses were performed by using R version 4.4.1 (R Core Team, 2024a) and RStudio version 2024.09.0.375 with the packages apatable (Stanley, 2023), finalfit (Harrison et al., 2024), flextable (Gohel & Skintzos, 2024), ggmice (Oberman, 2023), ggpubr (Kassambara, 2023a), MVN (Korkmaz et al., 2021), naniar (Tierney et al., 2024), officer (Gohel et al., 2024), olsrr (Hebbali, 2024), psfmi (Heymans, 2023), psych (Revelle, 2023), rmarkdown (Allaire et al., 2023), texreg (Leifeld & Zucca, 2024), tidyverse (Wickham, 2023), and writexl (Ooms, 2025).

7.3.6 Transparency and Openness

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study, and the study follows JARS reporting guidelines for quantitative research (Appelbaum et al., 2018). Additionally, this study‘s analysis protocol was preregistered after data had been collected but before analyses were undertaken. In the preregistration, we intended to additionally investigate the effects of school support during COVID-19. However, after observing correlations of the school support variable and taking a closer look at the measured item, we realized that our item was not a valid indicator for school support but was instead confounded with need for support (“During the last school year, my/our child received additional support (e.g. by teachers or peers) when needed.“). To reduce the study's complexity, we will not further report on school support in this study. We also indicated explorative analyses on childcare duration in years and intensity in hours in the preregistration. As the intensity variable had too many missing data points and covariance coverages below .75, we also will not further investigate childcare intensity. These and all other changes of the study design compared to the initial preregistration (Kaufmann, Keller, et al., 2025) are reported in a Transparent Changes document.

This document, along with other supplemental materials, is available at https://osf.io/ks2p8/?view_only=30901253512442 47b06501220525e433. While questionnaires and test items are not publicly available, the datasets used during the current study were collected as part of the ÉpStan by LUCET and are available after consultation with the authors. We also acknowledge the use of Open AI's ChatGPT (2024) for linguistic support and grammar editing, Perplexity AI (2025) as a search engine for coding and statistics queries, as well as Microsoft's Copilot (2025) for both. Suggestions were reviewed and, if applicable, cross-referenced before being integrated by the authors, who take full responsibility for the contents of this article.

7.4 Results

7.4.1 Early Childcare and Academic Performance

First, we present the results of the path analyses with childcare attendance (see Table 7), then report the results of the exploratory path analyses with childcare duration.

In the model without moderation terms, path coefficients of childcare on all performance domains in Grades 1 to 5 were non-significant and mixed in their directionality, indicating there was no overall positive relationship between childcare attendance and academic performance across the entire cohort. Instead, previous performances and child demographics significantly explained the performances.

The model including moderation terms had a slightly better fit with the data than the previous model (AICno moderation = 51,194 vs. AICwith moderation = 51,192). Figure 17 shows the path coefficients of primary and secondary hypotheses in a path diagram (see Figure A8 for the path coefficients of model assumptions). Only four of the moderation paths reached significance; one of them was a moderation by SES, and three of them were moderations by HL. SES moderated the association between childcare attendance and reading in Grade 3 in the opposite direction than expected (b = 0.08, p = .004). The compound correlation of r = .14 indicates a small moderation effect. This means that children with higher SES benefited more from attending childcare in their reading comprehension in Grade 3 than those with lower SES. HL moderated the association between childcare attendance and mathematics in Grade 5 (b = -0.10, p =.041), reading in Grade 3 (b = -0.16, p = .010), and mathematics in Grade 1 (b = - 0.18, p = .014) in the expected direction. This means that children not speaking the language of instruction at home either benefited more or suffered less in some academic domains if they had attended childcare. Compound correlations indicated small moderation effects (r = |.11|–|.17|).

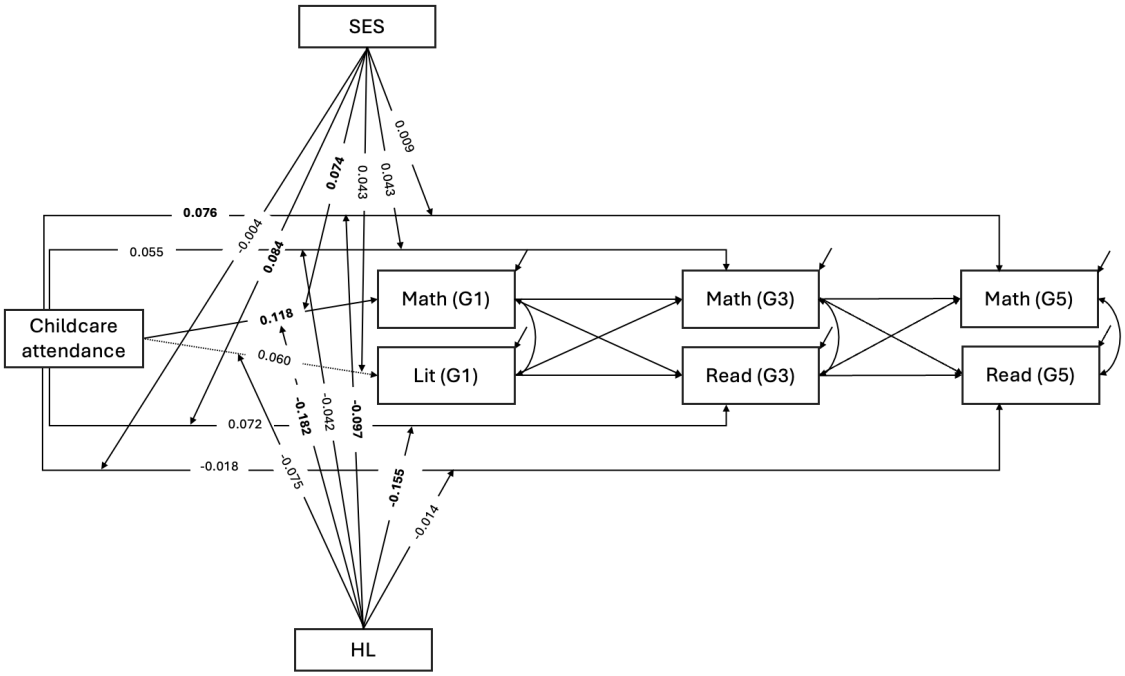
Table 7. *Results of path analyses with childcare attendance*

		Model without IA			Model with IA		
Outcome	Predictor	*b*	*SE b*	β	*b*	*SE b*	β
Math (G5)	Math (G3)	0.707***	0.014	0.704	0.707***	0.014	0.704
	Read (G3)	0.084***	0.014	0.084	0.083***	0.014	0.083
	Childcare (1 = attended)	0.017	0.023	0.007	0.076*	0.035	0.033
	SES	0.081***	0.010	0.081	0.074***	0.020	0.074
	HL (1 = speaks LI)	-0.047*	0.021	-0.023	0.028	0.042	0.014
	SES x Childcare				0.009	0.023	0.007
	HL x Childcare				-0.097*	0.048	-0.047
Read (G5)	Read (G3)	0.575***	0.014	0.575	0.575***	0.014	0.575
	Math (G3)	0.214***	0.013	0.215	0.214***	0.013	0.215
	Childcare (1 = attended)	-0.026	0.022	-0.012	-0.018	0.035	-0.008
	SES	0.080***	0.010	0.080	0.082***	0.020	0.083
	HL (1 = speaks LI)	0.159***	0.021	0.080	0.169***	0.041	0.085
	SES x Childcare				-0.004	0.023	-0.003
	HL x Childcare				-0.014	0.046	-0.007
Math (G3)	Math (G1)	0.540***	0.017	0.543	0.539***	0.017	0.542
	Lit (G1)	0.190***	0.015	0.190	0.190***	0.015	0.190
	Childcare (1 = attended)	0.026	0.025	0.011	0.055	0.041	0.024
	SES	0.108***	0.012	0.108	0.076***	0.022	0.077
	HL (1 = speaks LI)	0.074**	0.023	0.037	0.108*	0.046	0.054
	SES x Childcare				0.043	0.025	0.037
	HL x Childcare				-0.042	0.053	-0.021
Read (G3)	Lit (G1)	0.335***	0.017	0.336	0.336***	0.017	0.337
	Math (G1)	0.184***	0.017	0.185	0.181***	0.017	0.183
	Childcare (1 = attended)	-0.027	0.028	-0.012	0.072	0.045	0.032
	SES	0.141***	0.013	0.141	0.078**	0.026	0.078
	HL (1 = speaks LI)	0.500***	0.026	0.251	0.622***	0.053	0.312
	SES x Childcare				0.084**	0.029	0.072
	HL x Childcare				-0.155*	0.060	-0.076
Math (G1)	Childcare (1 = attended)	0.003	0.035	0.001	0.118*	0.058	0.051
	SES	0.253***	0.016	0.252	0.196***	0.030	0.196
	HL (1 = speaks LI)	0.138***	0.032	0.069	0.279***	0.065	0.139
	SES x Childcare				0.074*	0.035	0.063
	HL x Childcare				-0.182*	0.074	-0.089
Lit (G1)	Childcare (1 = attended)	0.012	0.036	0.005	0.060	0.057	0.026
	SES	0.246***	0.016	0.247	0.214***	0.031	0.214
	HL (1 = speaks LI)	0.176***	0.031	0.088	0.234***	0.066	0.117
	SES x Childcare				0.043	0.036	0.037
	HL x Childcare				-0.075	0.075	-0.036

Note. N = 3,943. Math = mathematics; Read = reading; Lit = early literacy; LI = language of instruction; HL = home language; SES = socioeconomic status. Performance variables and SES were standardized. * $p < .05$. ** $p < .01$, *** $p > .001$.

The path coefficients for attendance in the moderation models indicate the association of childcare with performance when both SES and HL are zero, i.e., for students with average SES who do not speak the language of instruction at home. For this group, childcare attendance was beneficial for mathematics performance in Grade 5 (b = 0.08, p = .032) and Grade 1 (b = 0.12, p = .041), while no significant relationship was found to reading in Grade 3 (b = 0.07, p = .111). Post-hoc analyses with a reversed HL variable showed that for children of average SES who spoke the language of instruction at home, there was a non-significant association between their childcare attendance and mathematics performance in Grade 5 (b = -.02, p =.492) and Grade 1 (b = -.06, p =.160), but a significantly negative association between childcare and reading in Grade 3 (b = -.08, p =.029). All these associations had (very) small effect sizes (compound r = |.05|–|.11|).

Figure 17. *Primary and secondary path coefficients (attendance model)*



Note. SES = socioeconomic status; HL = home language. This path diagram shows only part of the estimated paths for clarity. The rest of the paths are reported in the Appendix (see A2.8). Coefficients presented are unstandardized linear regression coefficients. Bold numbers represent significant relations (p < .05).

7.4.2 Exploratory Analyses with Childcare Duration

In this section, we present the results of exploratory path analyses including childcare duration in years instead of childcare attendance (see Table 8).

Table 8. *Results of path analyses with childcare duration*

		Duration without IA			Duration with IA		
		b	*SE b*	β	*b*	*SE b*	β
Math (G5)	Math (G3)	0.707***	0.014	0.703	0.707***	0.014	0.703
	Read (G3)	0.085***	0.014	0.085	0.085***	0.014	0.084
	Years in childcare	0.009	0.007	0.012	0.014	0.010	0.019
	SES	0.081***	0.010	0.081	0.077***	0.017	0.077
	HL (1 = speaks LI)	-0.045*	0.021	-0.022	-0.027	0.036	-0.013
	SES x Years				0.002	0.007	0.005
	HL x Years				-0.009	0.014	-0.012
Read (G5)	Read (G3)	0.574***	0.014	0.575	0.573***	0.014	0.574
	Math (G3)	0.214***	0.013	0.215	0.214***	0.013	0.215
	Years in childcare	-0.008	0.007	-0.011	0.006	0.010	0.009
	SES	0.079***	0.010	0.080	0.072***	0.017	0.072
	HL (1 = speaks LI)	0.158***	0.021	0.080	0.21***	0.035	0.106
	SES x Years				0.004	0.007	0.009
	HL x Years				-0.025	0.014	-0.034
Math (G3)	Math (G1)	0.54***	0.017	0.543	0.539***	0.017	0.542
	Lit (G1)	0.19***	0.015	0.190	0.19***	0.015	0.190
	Years in childcare	-0.001	0.008	-0.001	0.006	0.012	0.008
	SES	0.109***	0.012	0.109	0.085***	0.019	0.085
	HL (1 = speaks LI)	0.071**	0.023	0.036	0.093*	0.039	0.047
	SES x Years				0.013	0.008	0.030
	HL x Years				-0.010	0.016	-0.014
Read (G3)	Lit (G1)	0.336***	0.017	0.336	0.336***	0.017	0.337
	Math (G1)	0.184***	0.017	0.185	0.182***	0.017	0.183
	Years in childcare	-0.034***	0.009	-0.048	-0.008	0.013	-0.011
	SES	0.142***	0.013	0.143	0.114***	0.022	0.114
	HL (1 = speaks LI)	0.488***	0.026	0.245	0.584***	0.044	0.293
	SES x Years				0.014	0.009	0.033
	HL x Years				-0.047*	0.018	-0.063
Math (G1)	Years in childcare	0.006	0.011	0.009	0.037*	0.017	0.052
	SES	0.253***	0.016	0.252	0.216***	0.026	0.215
	HL (1 = speaks LI)	0.14***	0.032	0.070	0.25***	0.055	0.125
	SES x Years				0.018	0.011	0.043
	HL x Years				-0.054*	0.023	-0.072
Lit (G1)	Years in childcare	0.006	0.011	0.009	0.023	0.017	0.033
	SES	0.246***	0.016	0.247	0.242***	0.026	0.242
	HL (1 = speaks LI)	0.177***	0.032	0.089	0.239***	0.055	0.120
	SES x Years				0.002	0.011	0.004
	HL x Years				-0.031	0.022	-0.042

Note. N = 3,943. Math = mathematics; Read = reading; Lit = early literacy; LI = language of instruction; HL = home language; SES = socioeconomic status. Performance variables and SES were standardized. * $p < .05$. ** $p < .01$, *** $p > .001$.

In the model without moderations, the path coefficients of childcare duration on all performance domains but reading in Grade 3 were non-significant. Thus, across the entire sample, more years in childcare were related only to lower reading performance in Grade 3 (b = -0.03, $p < .001$). This compound correlation indicates a very small effect (r = |.04|).

The model with moderation terms showed a slightly worse fit with the data than the previous model (AICno moderation = 51,179 vs. AICwith moderation = 51,182) as it penalizes the number of parameters and here, many of the newly introduced parameters were not significant. However, among the moderation paths, two were significant: HL moderated the relationship between childcare duration and reading performance in Grade 3 (b = -0.05, p = .010) as well as mathematics performance in Grade 1 (b = -.05, p = .017) in the hypothesized direction. The effect size was small (r = |.10|–|.13|). Students of average SES who did not speak the language of instruction at home did not show a significant association between duration and reading in Grade 3 (b = -.01, p = .556) but a significantly positive association between duration and mathematics in Grade 1 (b = 0.04, p = .030). The reverse HL model indicated that students of average SES who spoke the language of instruction at home performed significantly lower in reading in Grade 3 with more years in childcare (b = -0.05, p < .001) and were not significantly impacted in their Grade 1 mathematics (b = -0.02, p = .252). Compound correlations indicated very small to small effect sizes (r = |.04|–|.10|).

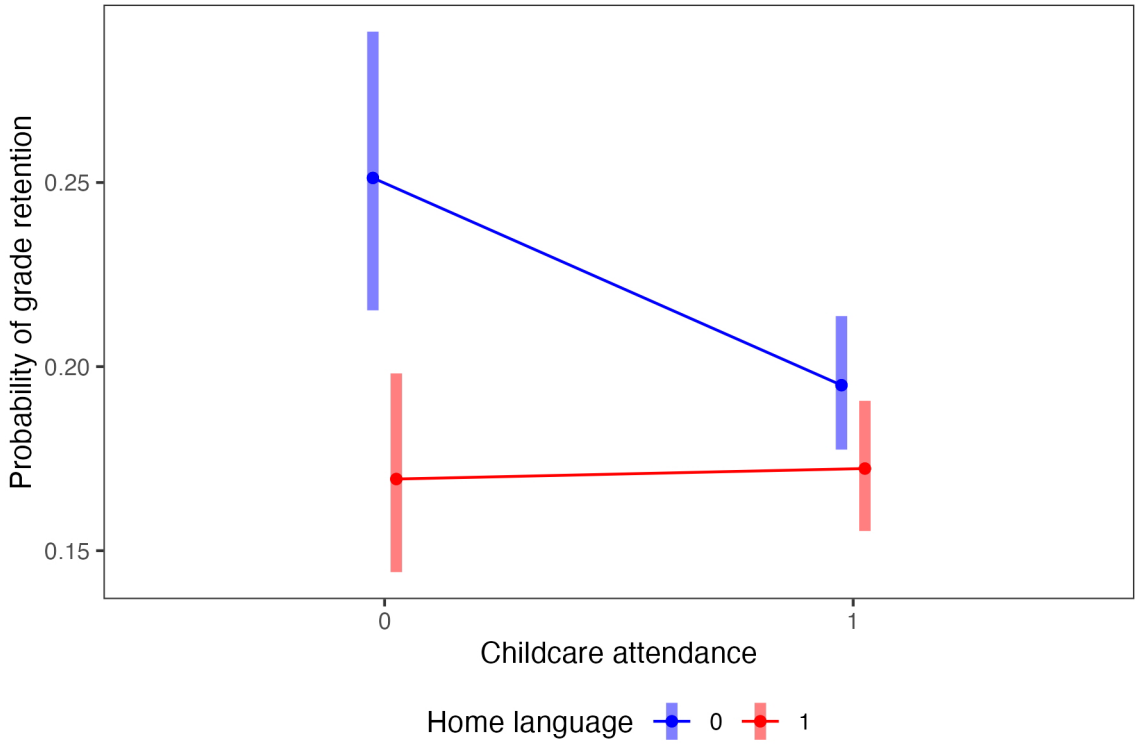
7.4.3 Early Childcare and Grade Retention

The results of all logistic regression analyses on grade repetition are presented in Table 9.

In the analysis without moderations, childcare attendance was not significantly associated with grade retention across the entire cohort (b = -0.13, p = .103). In the model with moderation terms, we see that this relationship was moderated by HL (b = 0.35, p = .031). More specifically, childcare attendance significantly predicted a lower chance of grade retention for children not speaking the language of instruction at home (contrast with Tukey adjustment: odds ratio = 1.39, SE = .16, p = 0.031), but not for children that spoke the language of instruction at home (contrast with Tukey adjustment: odds ratio = 0.98, SE = .11, p = 0.998). The moderation effect was small (β = |.15|) and is visualized in Figure 18. In other words, for

students with average SES that spoke the language of instruction at home, the probability of grade retention was estimated to stay at 17%, no matter if they attended childcare or not. For students with average SES that did not speak the language of instruction at home, their estimated probability of grade retention decreased from 25% to 19% if they attended childcare. SES did not significantly moderate the relationship between grade retention and childcare attendance (b = -0.08, p = 0.326).

Figure 18. *Interaction between home language and childcare attendance*



Note. Estimated marginal means of grade retention probability are shown for childcare attendance groups in combination with the home language group. Error bars represent confidence intervals on the 95% level. Home language = 1 are students speaking the language of instruction at home.

7.4.4 Exploratory Analyses with Childcare Duration

Now, we present the exploratory results of the logistic regression analysis examining the relationship between childcare duration and grade repetition (see Table 9). The model without moderation coefficients reveals a significant association between childcare duration and grade retention across the entire sample (b = -0.23, p = .005), with a lower probability of

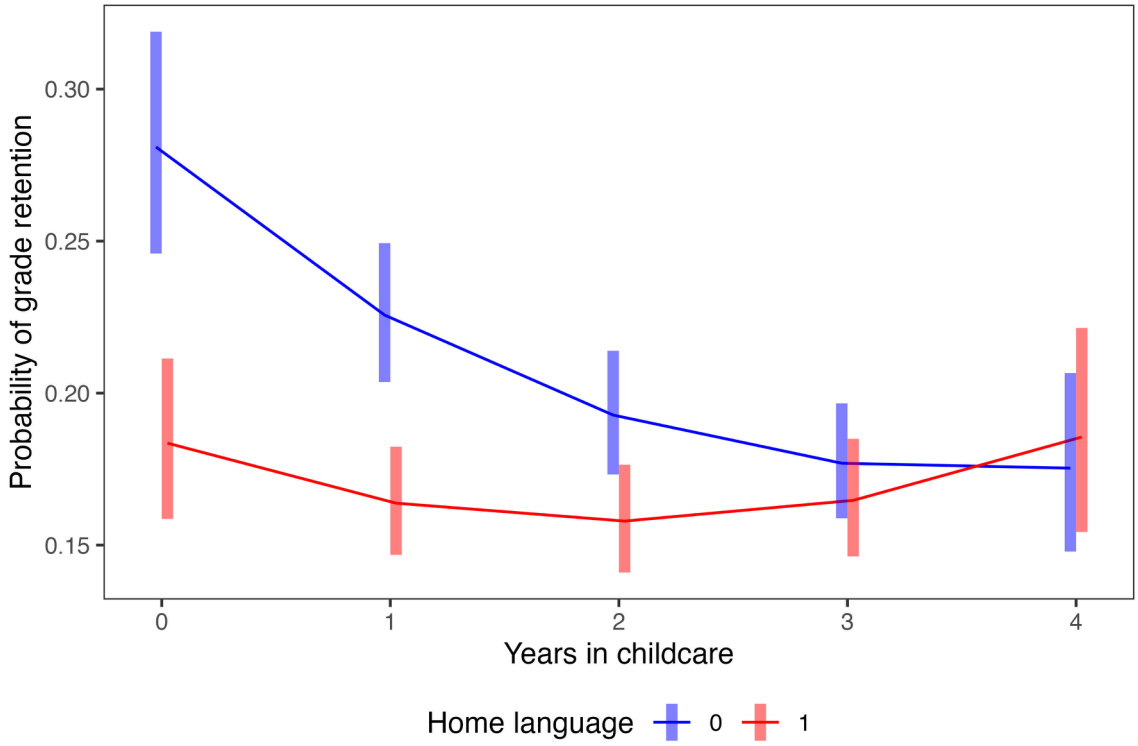
Table 9. *Results of logistic regressions with grade retention as criterion*

	Childcare attendance				Childcare duration			
	without interaction		with interaction		without interaction		with interaction	
	b (SE)	β (*SE*)	*b (SE)*	β (*SE*)	*b (SE)*	β (*SE*)	*b (SE)*	β (*SE*)
(Intercept)	-1.25 (0.08)***	-1.34 (0.05)***	-1.09 (0.10)***	-1.34 (0.05)***	-1.15 (0.08)***	-1.34 (0.05)***	-0.94 (0.09)***	-1.34 (0.05)***
SES	-0.68 (0.04)***	-0.68 (0.04)***	-0.61 (0.07)***	-0.68 (0.04)***	-0.68 (0.04)***	-0.68 (0.04)***	-0.52 (0.06)***	-0.68 (0.04)***
HL (1 = speaks LI)	-0.25 (0.07)***	-0.25 (0.07)***	-0.50 (0.14)***	-0.24 (0.07)***	-0.25 (0.07)***	-0.25 (0.07)***	-0.55 (0.12)***	-0.25 (0.07)***
Childcare (1 = attended)	-0.13 (0.08)	-0.06 (0.03)	-0.33 (0.12)**	-0.14 (0.05)**				
Childcare x SES			-0.08 (0.08)	-0.04 (0.04)				
Childcare x HL			0.35 (0.16)*	0.15 (0.07)*				
Years in childcare					-0.23 (0.08)**	-0.32 (0.12) **	-0.34 (0.09)***	-0.48 (0.12)***
Years in childcare^2					0.05 (0.02)*	0.25 (0.12)*	0.05 (0.02)*	0.26 (0.12)*
Years x SES							-0.08 (0.03)**	-0.12 (0.04)**
Years x HL							0.16 (0.05)**	0.22 (0.07)**
AIC (pooled)	5086.134	5086.134	5085.140	5085.140	5080.509	5080.509	5067.865	5067.865
Brier Scale (pooled)	0.077	0.077	0.079	0.079	0.078	0.078	0.081	0.081
R^2 (pooled)	0.118	0.118	0.119	0.119	0.120	0.120	0.124	0.124

Note. N = 5,338. HL = home language; LI = language of instruction; SES = socioeconomic status. Standardized SES. *$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

grade retention observed in those who attended childcare for more years (medium effect, β = |.32|). It also shows a significant quadratic term of childcare duration (small effect, β =|.25|). Post-hoc analyses show the estimated mean probability of grade retention decreased from 21% at 0 years to 16% at 3 years and increased again to 18% at four years.

Figure 19. *Interaction between home language and childcare duration*



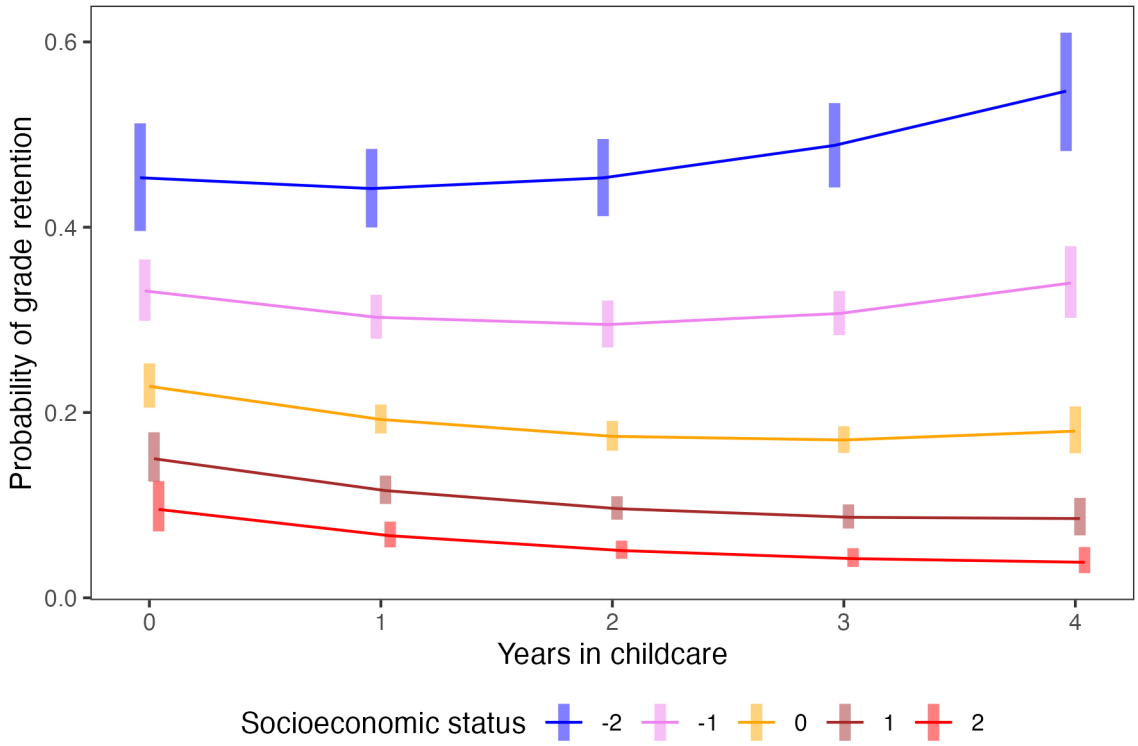
Note. Estimated marginal means of grade retention probability are shown for years in childcare for each home language group. Error bars represent confidence intervals on the 95% level. Home language = 1 are students speaking the language of instruction at home.

In the moderation model, we see that the association between childcare duration and grade retention was moderated between HL (b = .16, p = .002) as well as SES (b = -.08, p = .002). Moderation effects were small (β = |.12|–|.22|). Specifically, years in childcare were associated with a significantly lower probability of grade retention for children that did not speak the language of instruction at home (b = -0.34, p < .001), but not for those that spoke the language of instruction at home (estimated trend of childcare years = .00, 95% CI [-.07, .07]).

Figure 19 illustrates that students with an average SES that spoke the language of instruction at home had a probability of grade retention of 18% with 0 years in childcare, 16% with 2 years in childcare, and 20% with 4 years in childcare. Students of average SES that did not speak the language of instruction at home reduced their grade retention probability from 28% at 0 years to 18% at 3–4 years in childcare. This also shows the quadratic effect of childcare duration (small effect, β = |.26|).

Additionally, the significant moderation by SES indicated that children with higher SES benefited more strongly from full years in childcare than those with lower SES (contrasts between 0 and 4 years: odds ratio = 0.69, *SE* = .14, *p* = 0.055 for low SES; odds ratio = 1.89, *SE* = .34, p < 0.001 for high SES). Figure 20 illustrates the moderation and shows that for students with high and medium SES, the probability of grade retention decreased slightly with

Figure 20. *Interaction between socioeconomic status and childcare duration*



Note. Estimated marginal means of grade retention probability are shown for years in childcare for different values of socioeconomic status (SES). Error bars represent confidence intervals on the 95% level. SES is z-standardized.

more years in childcare. Children in the bottom 2.1% of the SES spectrum, however, showed an increased grade retention probability, especially at 4 years of childcare attendance.

7.5 Discussion

This paper aimed to investigate whether attendance and duration of early childcare were positively related to academic performance and trajectories, and whether this relationship was stronger for disadvantaged groups, using school monitoring data (ÉpStan) from Luxembourg from 2018 to 2023. In short, we did not find strong evidence that early childcare attendance was associated across the entire cohort with better academic performance or lower grade retention in this time period. Instead, our findings indicate that early childcare outcomes mostly depended on the population attending. We found that the disadvantaged home language group benefited more from early childcare attendance in terms of reduced grade retention and improvements in some, but not all, academic performances. Socioeconomically disadvantaged groups, however, seemed to benefit less than groups with high SES in at least a few outcomes.

We now address our findings in detail, ordered by primary, secondary, and exploratory findings.

7.5.1 Primary Findings

Our hypothesis of a generally positive early childcare effect on academic performance and grade retention was not confirmed. This is in line with previous findings from Luxembourg that show non-significant short-term associations between childcare attendance and Grade 1 mathematics and early literacy in the years 2015 to 2021 (Hornung et al., 2023). While international findings point towards a positive early childcare impact in general, stronger evidence exists for ECEC offers for older children between 3 and 5 than for younger children between 0 and 3 (Melhuish et al., 2015). Next to the type of ECEC, characteristics of the ECEC system might also play a role. Similar to our study, zero impact findings across the entire

sample have been found in a longitudinal Australian study using school monitoring data from Grades 3 to 9. In this study, attending any type of ECEC from age 0 to 6 explained only around 1% of school achievement (Little et al., 2020). In the US, early childcare effects found in the first school years did not persist in the long term (Esping-Andersen et al., 2012). Our results thus mirror more closely these findings from the heterogeneous and partly private childcare system of Australia and the US than findings of stronger childcare effects from more homogenous and public childcare systems in Denmark or Chile (Cortázar et al., 2020; Esping-Andersen et al., 2012). The weak associations in our study may, as such, point towards a heterogeneous nature of childcare service quality in Luxembourg beyond baseline quality requirements (OECD, 2022b).

Children not speaking the language of instruction at home benefited more from childcare attendance in their Grade 5 mathematics, Grade 3 reading, and grade retention than children that speak the language of instruction at home. This extends the previous finding that the association between pre-K attendance and early academic outcomes is stronger and more beneficial for dual language learners (Ansari et al., 2021) and shows that this moderation effect can also be present in long-term outcomes. Thus, our results indicate that exposure and contact with competent speakers of the language of instruction (i.e., educators in childcare) can especially benefit those who would otherwise not come into contact with this language this early.

Contrary to our hypothesis, SES was not a significant moderator in most cases. In Grade 3, childcare attenders with high SES even benefited more in their reading performance than those with low SES. Such a Matthew effect, summed up as "the rich get richer ", is an uncommon finding—most studies point in the other direction (Bennett, 2012; Burger, 2010). One possible explanation for this finding might be that families with high SES may have more resources (e.g., knowledge, time, money) to ensure their children attend centers with the

highest quality provision, thus profiting more from attendance. Location and availability of high-quality childcare might also play a role: private centers might offer lower service quality in deprived neighborhoods than in other places (Mathers & Smees, 2014; OECD, 2025).

7.5.2 Secondary Findings

Nearly all model assumptions were confirmed. Prior knowledge did indeed predict later knowledge. This is a well-established finding, illustrated by Hattie (2010), as learning new content is always constructed on prior knowledge (Bada, 2015). Disadvantaged children showed lower academic performance and were retained more frequently than their peers. This fits in very well with literature showing achievement gaps based on student's backgrounds to persist or even increase internationally (Broer et al., 2019; Chmielewski, 2019). While early childcare was not significantly associated with mathematics and early literacy in Grade 1 across the entire cohort, children not speaking the language of instruction at home did benefit from early childcare in their mathematics in Grade 1, only partially confirming our secondary hypotheses. This finding is particularly noteworthy, as previous cross-sectional studies on Luxembourgish early childcare across six cohorts (2015–2021) did not show a similar moderation effect for Grade 1 performance (Hornung et al., 2023). However, this earlier study employed a home language variable that categorized children by specific language groups, rather than distinguishing between speakers and non-speakers of the language of instruction at home. Consequently, our current finding may either reflect a lack of stability—suggesting the effect may not replicate across all cohorts—or it may indicate that using a broader, theory-driven home language variable with only two categories enhanced statistical power and enabled the detection of this effect.

7.5.3 Exploratory Findings

To our surprise, no curvilinear effect of childcare duration could be found in regard to performance. A curvilinear effect might have been able to explain the unexpected negative association of childcare duration and reading in Grade 3 and the otherwise nonsignificant duration effects, as most other studies have found either a positive or a curvilinear effect of childcare duration so far (Balladares & Kankaraš, 2020; Bennett, 2012). This lackluster result on the full population level, showing neither significant curvilinear nor positive linear effects of duration, might indicate that duration and content of ECEC are intrinsically connected and thus suggest that effects of duration depend critically on the specific childcare and its quality (Wasik & Snell, 2019). Our non-significant findings may thus either point to the relative irrelevance of childcare duration in regard to performance or instead illustrate the diverse and heterogeneous nature of childcare services in Luxembourg where different providers have different "optimal" durations, depending on whether they succeed in creating a sufficiently enriching and interactive environment for each age group (W. Li et al., 2020).

The probability of grade retention was lower for those who spent more years in childcare. Additional to this, there was a significant curvilinear trend, i.e., after the initial decrease in grade retention with increasing years, the probability of being retained increased again with a fourth year in childcare. Thus, childcare attendance for some years might be a buffer against grade retention, while there is also a "too much" of time in childcare. We see two possible explanations for this. Spending a fourth year in childcare might mean children do not attend Luxembourg's more effective voluntary preschool offer for three-to-four-year-olds (Hornung et al., 2023). Secondly, a longer duration in childcare is closely correlated with an earlier entry into childcare (Barnes & Melhuish, 2017). Such early entries, e.g., under the age of 18 months, have been found to have adverse effects on behavioral outcomes (L. M. Berger

et al., 2021; Sylva et al., 2004) and fewer cognitive benefits than slightly later entries (Loeb et al., 2007).

Children in the disadvantaged HL group exhibited less negative reading outcomes in Grade 3 and lower rates of grade retention following a longer childcare attendance. This tendency aligns with findings from studies examining more short-term outcomes, such as Yazejian et al. (2015) or Hornung et al. (2023). They found that dual language learners in the US and Luxembourg needed a longer duration of childcare to show higher receptive language skills before and in Grade 1. Monolingual children managed to score well even after late entry into childcare. This indicates that, for language acquisition in childcare, an early start is helpful.

On the other hand, we find an unintuitive SES moderation. While children with high SES benefited most from medium-high childcare duration of 3 to 4 years in their grade retention rates, children with very low SES, who present generally with much higher retention rates, benefited more from a shorter childcare duration of 1 to 2 years. A four-year duration of childcare attendance was even associated with the highest rates of grade retention among children with low SES. This counterintuitive trend is puzzling and raises important questions about the equitable accessibility of high-quality childcare in Luxembourg. It also suggests that missing the voluntary preschool program for three-year-olds—by instead attending childcare for a fourth year—may be particularly disadvantageous for children with low SES.

Interestingly, the most consistent moderation effects could be found in regard to reading in Grade 3 and grade retention. This may be due to a greater variance and wider achievement gaps in these outcomes. In particular, the COVID-19 lockdowns coincided here with a key developmental period, in which foundational reading skills such as letter decoding, typically introduced in Grades 1 and 2 and assessed in Grade 3, would have been honed in the classroom. Thus, the findings suggest that the benefits of childcare are especially visible when educational

inequalities are more substantial, underscoring the importance of ensuring equitable access to childcare for children from diverse linguistic backgrounds.

7.5.4 Limitations

We used standardized academic performance data of a nearly complete cohort in Luxembourg and analysed it in a comprehensive model via path analysis. This prevented the accumulation of alpha error and acknowledged the multiple ways school performance and grade retention are impacted. The available school monitoring data allowed a unique insight into an entire cohort, from the extreme cases to the mainstream trend.

However, several limitations should be noted. First, childcare attendance in our study was naturally observed, rather than randomly assigned which introduces potential selection bias. As shown in previous research (Hornung et al., 2023), attendance in childcare thus differs between families, possibly influenced by cultural values, available resources, and family networks. Although we controlled key variables such as home language and SES, other relevant background factors were not included (e.g., working hours, or family structure). To address potential confounding factors, future studies should consider statistical techniques like propensity score matching, which accounts for pre-existing differences in outcome variables by matching similar childcare attenders and non-attenders.

Second, as attendance information was collected retrospectively through broad parent questionnaires, data may have been influenced by lack of information, memory biases, or social desirability effects (Grimm, 2010; Varmuza et al., 2019). Moreover, the questionnaire items may not have been sufficiently detailed to deal with non-standard childcare trajectories, such as breaks in attendance or changes in providers.

Third, more thorough interpretations of our findings would require insight into the current "black box" of childcare services in Luxembourg. Many findings report (process) quality of childcare as the key variable instead of childcare attendance (Ulferts et al., 2019; van

Huizen & Plantenga, 2018) which, of course, varies between different providers and services. Additionally, in the multilingual country of Luxembourg, even the languages in childcare services can vary, as only in 2017, after our sample had attended childcare, a reform (MENJE et al., 2021) made it obligatory for childcare services to promote Luxembourgish and French to profit from government funding. Even before, a majority of childcare services included Luxembourgish as the lingua franca (Hornung et al., 2023), however, observational or self-report data of childcare staff is missing. Data on quality as well as language use and activities in childcare would be necessary, for example, to investigate a possible explanation for why children with higher SES benefited more from childcare. Thus, it could give us critical insight into the factors necessary to foster a good and fair start in(to) school for all children.

Last but not least, more detailed information on the students' language background and home learning environment was not considered here. There is reason to believe that the broad categories of speaking the language of instruction at home or not, did not fully capture the nuances and complexities of the multilingual homes in Luxembourg. Previous studies (Kaufmann, Ottenbacher, et al., 2025; Kohl et al., 2019; Wealer et al., 2025) find that, at least, further differentiating between those only speaking the language of instruction at home and those who do so bilingually would be beneficial. Such a categorical variable could not be included in the path model here, but should be considered in future publications. Additionally, the counterintuitive SES associations might also be connected to the home learning environment, as McCartney et al. (2007) find indirect childcare effects over an improved home learning environment. The quality of the home learning environment also seems to be critical for academic performance in the short and long-term (Dong et al., 2020; Lehrl, Evangelou, et al., 2020).

7.5.5 Implications

This study found small and mostly non-significant associations of early childcare with academic performance between Grades 1 and 5. In the childcare literature, bigger effect sizes have been found in studies investigating targeted (intervention) programs where consistent high quality were ensured. Investigating the full scope of a country's childcare system, consisting of numerous public and private providers, services, and care philosophies, naturally increases the variance of effects on performance and grade retention. Nevertheless, our results deliver an interesting picture of small, but real patterns in the population. The moderation effects by HL are a helpful pointer that early experience of the language of instruction is crucially important for students not speaking the language of instruction at home.

However, the counterintuitive SES moderation shows that ensuring enough places in childcare and promoting high attendance is not an easy fix for inequalities and can indeed, on a country level, even contribute to growing achievement gaps. The reasons behind this pattern stand to be further investigated, however, there is reason to believe that differences in the quality of childcare provision play a role. Vandenbroeck and colleagues underline that "[h]ow early childhood education and care are provided is as important as whether it is provided" (Vandenbroeck et al., 2018, p. 5) and illustrate to policymakers that not only the generosity of spending but also the monitoring of outcomes and inputs is key to reaping the benefits of ECEC. It is a vital step that Luxembourg's control mechanisms for ECEC quality are already being further developed and expanded. As recommended by OECD (2022b), also broadening the focus to include interactions between ECEC staff and children in the monitoring, and prioritizing the work on a centrally organized and systematic collection of ECEC data would be an important step to truly realize the potential of high-quality childcare and ensure a level playing field for all children. Future studies will then be able to evaluate the impact of these new developments and see whether centers have indeed become more homogenous in quality.

It should not be neglected that the study is situated in the context of Luxembourg's emergency remote teaching periods during spring and autumn of 2020 and winter of 2021 (OECD, 2022a) due to the pandemic. All in all, "school closures amounted to 48 days of teaching in primary education" (OECD, 2022a, p. 134). Several aspects might have differed from non-emergency teaching periods. For example, the curriculum might have been compressed, testing more relaxed (UNESCO, 2020), and grade retention used more sparingly during the lockdown period (Wills, 2023), as seen in other countries. On the other hand, student performances might have been slightly more impacted by their home environment, parental support, and other factors contributing to resiliency (Goudeau et al., 2021; Grewenig et al., 2021). Luxembourg's education ministry has been generally able to support its schools with extra funding: For example, equal access to digital devices for remote learning was provided by lending devices to those without their own, while summer school courses were set up to help children revise the learning content and close learning gaps (Colling et al., 2024). Thus, no major general loss of learning performance across the country was observed in school monitoring; however, in some grades, increasing achievement gaps for disadvantaged HL groups could be noted (Colling et al., 2024). We can only speculate how this impacted childcare asociations in comparison to another time period. There are first findings that continued attendance in early childcare during COVID-19 was especially important for language skills of socioeconomically disadvantaged children (Davies et al., 2021, 2023). However, no other studies on a long-term or possible fade-out effect of childcare during the COVID-19 pandemic have been conducted so far, so it is unclear whether the small and mostly non-significant effect sizes here were due to the particular ECEC system of Luxembourg or due to rising inequalities and the increasing importance of other factors during the COVID-19 pandemic. In the future, it would be interesting to see this study replicated in a non-COVID-19 cohort to ensure transferability of our results.

7.6 Conclusion

This study examined early childcare attendance as a potential factor in promoting educational equity for disadvantaged students using large-scale, longitudinal school monitoring data of Luxembourg. While most of the academic performances assessed in Grades 3 and 5 during the COVID-19 period were not associated with early childcare attendance, associations with selected learning domains and grade retention indicated that even in a heterogeneous and diverse childcare system such as Luxembourg, there is some evidence of equity-promoting effects of early childcare attendance for children not speaking the language of instruction at home. In contrast, children of lower SES seemed to benefit less from early childcare in comparison to more advantaged peers in some outcomes, such as reading in Grade 3 and mathematics in Grade 5, which points towards possible mechanisms reinforcing inequalities. Monitoring and ensuring equal access to high-quality childcare provision may thus be one avenue of increasing equity, not only between children of different language backgrounds, but also socioeconomic backgrounds, which is and stays an important topic during and outside of pandemic times.

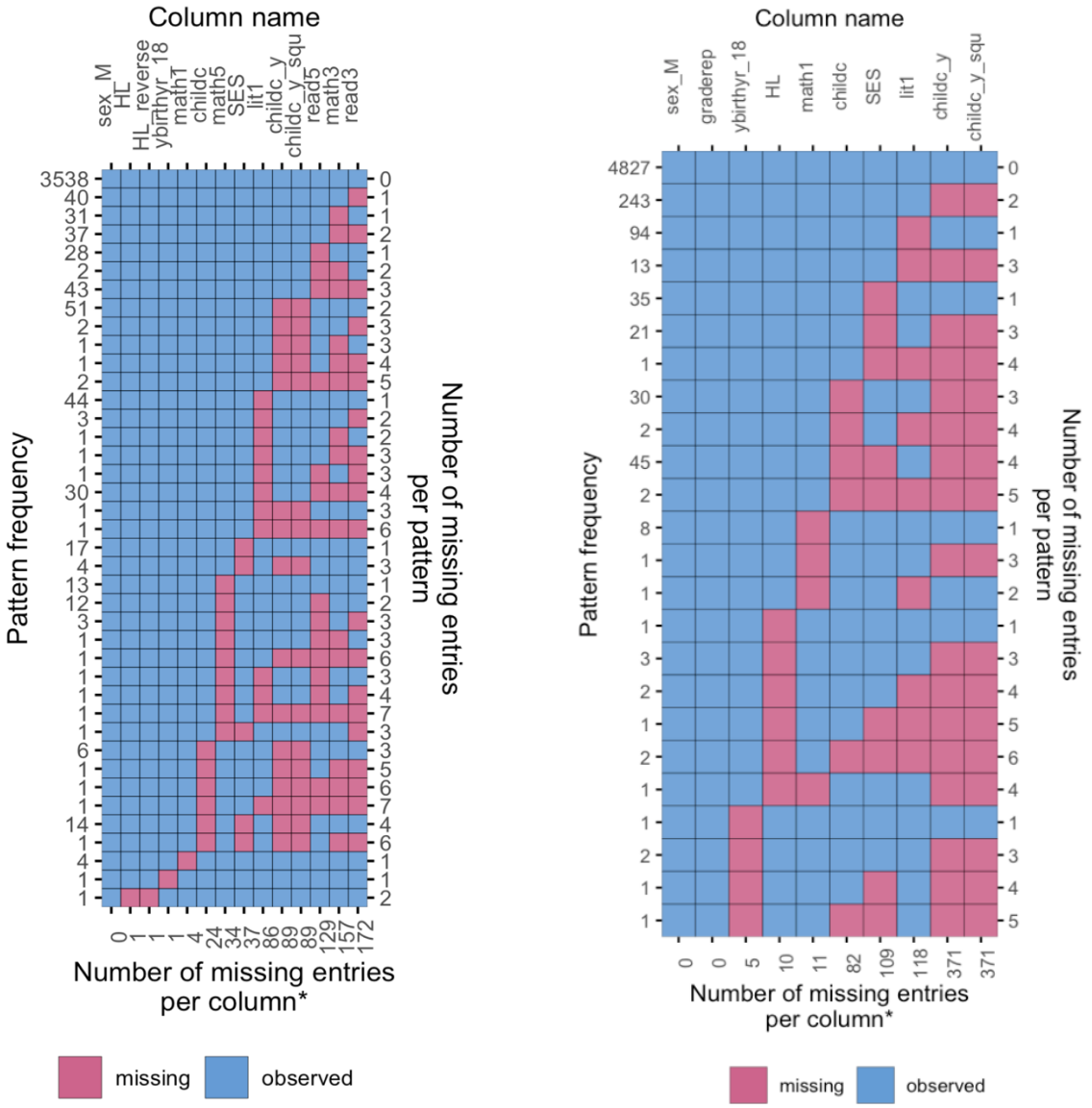
7.7 Appendix

Table A2.1. *Attrition information: Number of students assessed per year and grade*

Year	Grade	n
18	1	5469
19	1	28
19	3	8
20	1	1
20	3	4392
21	3	728
21	5	18
22	3	2
22	5	3943
23	5	991
23	7	119

Note. Based on original data before removing cases that skipped a school year.

Figure A2.2. *Missing data patterns*



Note. On the left, dataset for performance analyses; on the right, dataset for grade retention analyses.

Table A2.3. *Descriptive statistics for the logistic regression dataset*

Variable	*N*	*M*	*SD*	min	max	skew.	kurtosis
Mathematics (G1)	5,327	505.81	89.91	90.75	863.92	0.13	0.48
Early literacy (G1)	5,220	500.31	120.66	74.12	839.07	0.19	0.19
Childcare (1 = attended)	5,256	0.74	0.44	0.00	1.00	-1.07	-0.85
Years in childcare	4,967	1.93	1.42	0.00	4.00	-0.06	-1.30
Years in childcare^2	4,967	5.75	5.62	0.00	16.00	0.69	-0.81
SES	5,229	48.62	16.55	16.25	69.90	-0.20	-1.27
HL (1 = speaks LI)	5,328	0.51	0.50	0.00	1.00	-0.02	-2.00
Gender (1 = male)	5,338	0.51	0.50	0.00	1.00	-0.03	-2.00
Age (G1)	5,333	6.36	0.50	4.00	8.00	0.72	-0.80
Grade retention	5,338	0.21	0.41	0.00	1.00	1.42	0.01

Note. *n* = available data before imputation; skew = skewness; *M* = Mean; *SD* = Standard Deviation; LI = language of instruction.

Appendix A2.4. *Path model syntax*

```
fullmod <-'
#regression paths
math5 ~ math3 + read3 + childc + SES + HL + SES:childc + HL:childc
read5 ~ read3 + math3 + childc + SES + HL + SES:childc + HL:childc
math3 ~ math1 + lit1 + childc + SES + HL + SES:childc + HL:childc
read3 ~ lit1 + math1 + childc + SES + HL + SES:childc + HL:childc
math1 ~ childc + SES + HL + SES:childc + HL:childc
lit1 ~ childc + SES + HL + SES:childc + HL:childc

#residual variances
math5 ~~ math5
read5 ~~ read5
math3 ~~ math3
read3 ~~ read3
math1 ~~ math1
lit1 ~~ lit1

# (residual) covariances
math1 ~~ lit1
read3 ~~ math3
read5 ~~ math5
'
fullfit_imp_stand <-
  lavaan.mi::sem.mi(
    model = fullmod, data = EpstanAD_stand_imp, estimator = "MLR", fixed.x = TRUE
  )
dur_mod <-'
# regression model
math5 ~ math3 + read3 + childc_y + SES + HL + SES:childc_y + HL:childc_y
read5 ~ read3 + math3 + childc_y + SES + HL + SES:childc_y + HL:childc_y
math3 ~ math1 + lit1 + childc_y + SES + HL + SES:childc_y + HL:childc_y
read3 ~ lit1 + math1 + childc_y + SES + HL + SES:childc_y + HL:childc_y
math1 ~ childc_y + SES + HL + SES:childc_y + HL:childc_y
lit1 ~ childc_y + SES + HL + SES:childc_y + HL:childc_y

#residual variances
math5 ~~ math5
read5 ~~ read5
math3 ~~ math3
read3 ~~ read3
math1 ~~ math1
lit1 ~~ lit1

# (residual) covariances
math1 ~~ lit1
read3 ~~ math3
read5 ~~ math5
'
dur_fit_imp <-
  lavaan.mi::sem.mi(
    model = dur_mod, data = EpstanAD_stand_imp, estimator = "MLR", fixed.x = TRUE
  )
```

Table A2.5. *Means, standard deviations, and correlations with confidence intervals*

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9
1. Math (G5)	522.12	99.27									
2. Read (G5)	515.98	98.67	.60** [.58, .62]								
3. Math (G3)	508.57	110.82	.78** [.76, .79]	.60** [.58, .62]							
4. Read (G3)	519.74	126.79	.53** [.51, .55]	.75** [.74, .77]	.60** [.58, .62]						
5. Math (G1)	529.83	81.85	.65** [.63, .67]	.48** [.45, .50]	.69** [.68, .71]	.46** [.44, .49]					
6. Lit (G1)	532.94	110.33	.52** [.50, .54]	.48** [.45, .50]	.56** [.54, .59]	.52** [.50, .54]	.63** [.61, .65]				
7. Childcare (1 = attended)	0.74	0.44	.04* [.00, .07]	-.02 [-.05, .01]	.03 [-.00, .06]	-.02 [-.05, .01]	.02 [-.02, .05]	.02 [-.02, .05]			
8. Years in childcare	1.94	1.40	.01 [-.02, .04]	-.07** [-.10, -.04]	-.00 [-.03, .03]	-.08** [-.11, -.05]	.00 [-.03, .04]	.00 [-.03, .03]	.69** [.67, .70]		
9. SES	51.19	16.00	.32** [.29, .35]	.35** [.32, .37]	.30** [.27, .33]	.32** [.29, .35]	.26** [.23, .29]	.26** [.23, .29]	.08** [.05, .11]	.03 [-.01, .06]	
10. HL (1 = speaks LI)	0.54	0.50	.12** [.09, .15]	.33** [.30, .35]	.14** [.11, .17]	.34** [.31, .37]	.11** [.08, .14]	.13** [.10, .16]	-.09** [-.12, -.06]	-.14** [-.17, -.11]	.18** [.14, .21]

Note. M = mean; *SD* = standard deviation; HL = home language, LI = language of instruction; SES = socioeconomic status. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2014). * $p < .05$. ** $p < .01$.

Table A2.6. *Means, standard deviations, and correlations with confidence intervals*

Variable	*M*	*SD*	1	2	3	4	5	6
1. Childcare (1 = attended)	0.74	0.44						
2. Years in childcare	1.93	1.42	.68** [.66, .69]					
3. SES	48.62	16.55	.08** [.05, .11]	.01 [-.01, .04]				
4. HL (1 = speaks LI)	0.51	0.50	-.07** [-.10, -.05]	-.12** [-.14, -.09]	.18** [.15, .20]			
5. Gender (1 = male)	0.51	0.50	.02 [-.01, .04]	.00 [-.02, .03]	-.01 [-.03, .02]	.02 [-.01, .05]		
6. Birth year	2011.64	0.50	.01 [-.02, .04]	-.01 [-.04, .02]	.09** [.06, .12]	.04** [.01, .07]	-.03* [-.06, -.00]	
7. Grade retention (1 = retained)	0.21	0.41	-.04** [-.07, -.02]	-.03* [-.06, -.01]	-.27** [-.30, -.25]	-.09** [-.12, -.07]	.03* [.01, .06]	.02 [-.00, .05]

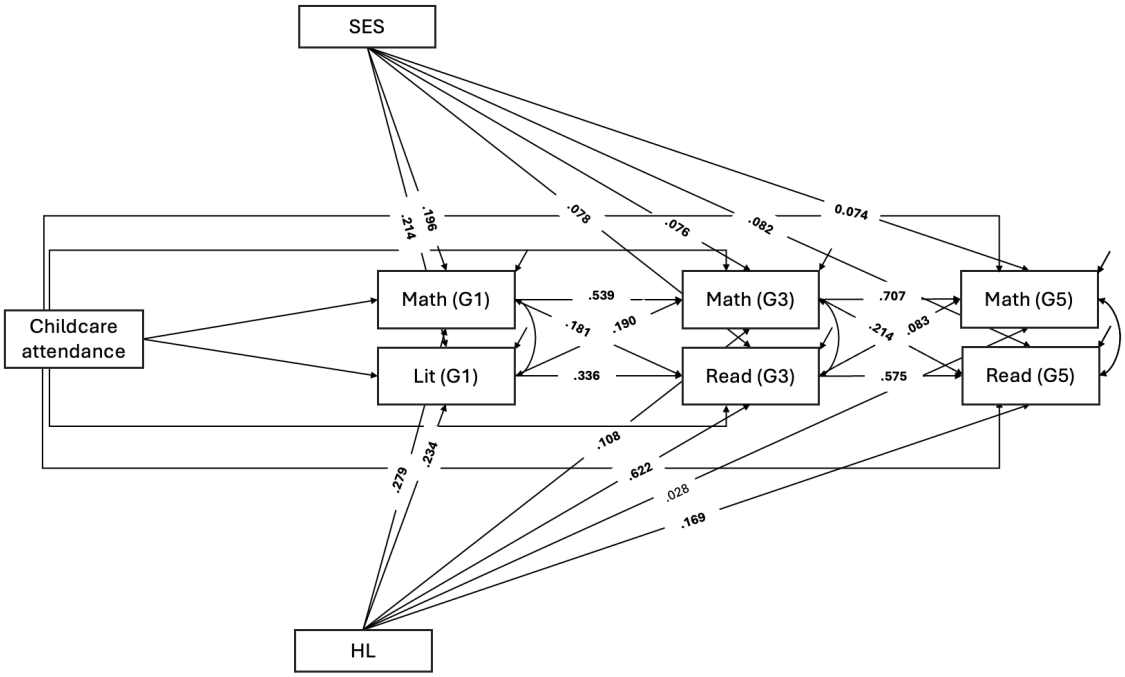
Note. M = mean; *SD* = standard deviation; HL = home language; LI = language of instruction; SES = socioeconomic status. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2014). * $p < .05$. ** $p < .01$.

Table A2.7. *Estimated model fit, covariances and variances for path analyses*

		Attendance without IA		Attendance with IA		Duration without IA		Duration with IA	
	Variable(s)	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*	Estimate	*SE*
Covariance									
	Math (G5) - Read (G5)	0.086***	0.007	0.086***	0.007	0.086***	0.007	0.086***	0.007
	Math (G3) - Read (G3)	0.210***	0.009	0.209***	0.009	0.210***	0.009	0.209***	0.009
	Math (G1) - Lit (G1)	0.559***	0.017	0.558***	0.017	0.559***	0.017	0.558***	0.017
Variance									
	Math (G5)	0.383***	0.011	0.383***	0.011	0.383***	0.011	0.383***	0.011
	Read (G5)	0.375***	0.010	0.375***	0.010	0.375***	0.010	0.375***	0.010
	Math (G3)	0.471***	0.012	0.471***	0.012	0.471***	0.012	0.471***	0.012
	Read (G3)	0.596***	0.014	0.594***	0.014	0.593***	0.014	0.592***	0.014
	Math (G1)	0.925***	0.024	0.923***	0.024	0.925***	0.024	0.923***	0.024
	Lit (G1)	0.915***	0.022	0.914***	0.022	0.915***	0.022	0.914***	0.022
R^2									
	Math (G5)	0.616		0.616		0.616		0.616	
	Read (G5)	0.619		0.619		0.619		0.619	
	Math (G3)	0.525		0.525		0.525		0.525	
	Read (G3)	0.395		0.397		0.397		0.398	
	Math (G1)	0.075		0.077		0.075		0.076	
	Lit (G1)	0.077		0.077		0.077		0.077	
Modelfit									
	χ^2 (df = 4)	192.844***		191.292***		191.848***		190.053***	
	CFI	0.987		0.987		0.987		0.988	
	RMSEA	0.109		0.109		0.109		0.109	
	SRMR	0.019		0.015		0.019		0.015	
	AIC	51,194.212		51,192.476		51,178.903		51,181.934	
Model info									
	N (parameters)	35		47		35		47	

Note. N = 3,943. *SE* = Standard Errors; IA = Interaction. Scaled by MLR estimator. ***$p < .001$.

Figure A2.8. *Path coefficients for model assumptions*



Note. SES = socioeconomic status; HL = home language. This path diagram shows only part of the estimated paths for clarity. The rest of the paths are reported in the test (see Figure 17). Coefficients presented are unstandardized linear regression coefficients. Bold numbers represent significant relations ($p < .05$).

8 Study 4

Language and book exposure are associated with receptive language and early literacy independent of home language group: A large-scale study in Luxembourg

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Abstract

The present study examined how exposure to the language of instruction and media in a diverse multilingual cohort of first graders in Luxembourg was associated with language and early literacy skills in the language of instruction. The study included three different home language groups, from children only speaking the languages of instruction (Luxembourgish and German) with their parents (n = 1,577), over children speaking additionally another language with their parents (n = 3,098) to children not speaking the language of instruction with their parents (n = 958). Linear regression analyses indicated that exposure to the language of instruction at home was positively associated with Luxembourgish listening comprehension and early literacy for all language groups, even while controlling for socioeconomic status and media exposure. Preschool attendance was only positively associated with language skills in children not speaking the languages of instruction with their parents. Higher frequency of book exposure, independent of the used language, was positively associated with higher language and literacy skills for nearly all home language groups. Video frequency was unrelated or negatively related to performance, depending on outcome and language group, while audio frequency was mostly unrelated to both language and literacy skills for the different home language groups. Results point towards an independent impact of exposure to both language and early literacy activities in multilingual student populations. This highlights the important role that the home language and literacy environment plays in fostering children's literacy acquisition.

Keywords: multilingual education system, media exposure, book exposure, video exposure, audio exposure, exposure to the language of instruction, language environment, preschool, literacy acquisition, listening comprehension, Luxembourg

8.1 Introduction

Children growing up multilingual often face challenges in developing literacy skills and tend to fall behind their monolingual peers in academic achievement (Hornung et al., 2021; UNESCO, 2016; Van Staden et al., 2016). Although different (and delayed) language and literacy development trajectories are typical for bi- or multilingual children, the existing gaps in language and literacy skills are significant and can have a lasting impact on academic success (Hoff, 2013). Given that early literacy is foundational for future literacy, academic success, and professional qualification (McLaughlin et al., 2014; Reed et al., 2017; Suggate et al., 2018), which should be equally accessible to all children, it is essential to explore early childhood factors that can positively or negatively influence the acquisition of the language of instruction (LI) and subsequent literacy development.

Bronfenbrenner's ecological systems theory (1977) illustrates how early child development is shaped by several interconnected systems, from immediate settings like family to broader societal influences such as media and culture. A large body of research has shown that a wide range of these environmental variables are related to children's development of language and early literacy (see Bonifacci et al., 2023). Notably, recent studies have investigated the role of the home language and literacy environment (HLLE, see Relyea et al., 2020), which builds on the previous notion of the home literacy environment, but adds the aspect of oral language use within the family, as this aspect is particularly critical for emergent multilingual children.

For the present study, we examined both HLLE variables, such as language and literacy exposure, and ancillary predictors, such as exposure to other types of media and attendance in preschool, an additional setting in which young children may experience the LI. Most existing research studies on language and media exposure have focused either on monolingual or bilingual school populations (Dong & Chow, 2022; e.g., Højen et al., 2021; Jing et al., 2023).

In a unique multilingual setting like Luxembourg—a trilingual country with three LI—the student population comprises (quasi) monolingual Luxembourgish speaking children, as well as a large group of successive bi- or multilingual and simultaneous bi- and multilingual children. Thus, it is important to question whether previously found associations of HLLE, media exposure, and preschool attendance can be replicated for different language groups or if they differ depending on academic outcome or language group. Thus, we investigated students' language and early literacy skills as further described below in a quantitative large-scale study in the multilingual setting of Luxembourg.

8.1.1 Early Literacy and Listening Comprehension are Key for Later Literacy

In this paper, we use the term 'literacy' to refer specifically to functional literacy (Verhoeven et al., 2008) derived from a perspective of reading and writing skills, in comparison to "literacies", a broader term describing the diversity of reading and writing practices in different contexts (Weth, 2016; Weth & Schroeder, 2022). *Early literacy* encompasses a range of different subskills, such as phonological awareness, alphabet knowledge, rapid automatized naming of letters and digits, phonological memory, and writing letters, which begin to develop in preschool before children start formal education (Juska-Bacher, 2013) and predict later literacy (Hornung et al., 2017a; Leppänen et al., 2008; Lonigan & Shanahan, 2009; Schmitterer & Schroeder, 2019) across different orthographies (see review, Landerl et al., 2022).

While evidence on differences between multilingual and monolingual children is mixed, a review indicated that multilingual children perform lower than monolinguals in early literacy assessments but may catch up in later years (see for a review, Hammer et al., 2014). In contrast, in Luxembourg, gaps in the early literacy skills between different language groups that exist already in first grade widen even more in later grades (Hornung et al., 2021).

A substantial body of research has demonstrated that these early literacy skills are necessary but not sufficient conditions for literacy development (Hogan et al., 2014; Landerl

et al., 2019; Melby-Lervåg et al., 2012; Storch & Whitehurst, 2002). Oral language skills in the LI are also crucial, especially for multilingual children (see Hammer et al., 2014; Hjetland et al., 2020).

Listening comprehension is an important prerequisite for literacy (Hogan et al., 2014). It is directly predictive of reading comprehension independently of decoding skills (Hogan et al., 2014; Kendeou et al., 2009), and also predicts the speed of growth in reading comprehension skills (Lervåg et al., 2018). Together, decoding skills and listening comprehension can explain almost all variation in early reading comprehension skills (Lervåg et al., 2018), while later reading comprehension skills have been found entirely explainable by listening comprehension (Adlof et al., 2006).

Listening comprehension, as the "ability to understand what one hears [... for] purposes such as understanding a story told at a dinner table or building a mental model while watching a cartoon on television" (Hogan et al., 2014, p. 5), is a complex construct. It relies on numerous cognitive and linguistic processes, including fundamental skills such as vocabulary, inferencing, and background knowledge (Hogan et al., 2014). The extent to which listening comprehension tests are influenced by these underlying abilities can vary (Hogan et al., 2014). For instance, assessments in the early years that include sentence- or word-picture matching tasks are likely to be closely related to vocabulary knowledge. Indeed, vocabulary skills are not only an important part of listening comprehension, but also a factor of particular relevance in the development of early literacy skills for multilingual children (Scarpino et al., 2011; Walley & Metsala, 2003) whose vocabulary in the majority language is often lower than that of monolingual children in the early years (see Hammer et al., 2014). As the listening comprehension test in the present study is closely related to vocabulary assessment, the following review of studies also includes vocabulary scores as an outcome.

8.1.2 Exposure to Languages in Different Contexts

To develop language and subsequent literacy skills, exposure to language matters (De Houwer, 2022; see review of Hammer et al., 2014). In studies on bilingual children, the amount of exposure to and usage of each language predicted children's language skills in the respective language (e.g., Scheele et al., 2010; Thordardottir, 2019). Independent of the frequency of exposure to words, the number of places and speakers have also been found to be significant for children's language development (Goldenberg et al., 2022). As outlined in Bronfenbrenner's ecological systems theory (1977), children encounter language across multiple interconnected contexts, from immediate settings such as family, preschool, and neighborhood to broader cultural influences such as mass media. The relevance of the various contexts described above for the development of the LI and early literacy skills is explored in more detail in the following sections.

Within the Family

Young children spend the majority of their time within the family setting, so interactions with parents, siblings, and extended family play a significant role in shaping their language and literacy development (Brushe et al., 2025; Gonzalez & Uhing, 2008). Studies have consistently shown that multilingual children demonstrate higher receptive language and early literacy skills in the LI when at least one parent speaks that language (Kaufmann, Ottenbacher, et al., 2025; Place & Hoff, 2011). This effect seems to be mediated by language use at home (Place & Hoff, 2011), which is in line with Vagh et al. (2009) showing larger LI vocabularies for bilingual children that spoke mostly the LI at home. Some evidence, however, suggests that if children had sufficient exposure to the LI at school and the community, maternal use of the LI was not associated with (accelerated) language development in the LI (Hammer et al., 2009; Højen & Bleses, 2023). A similar null effect was found in regard to early literacy skills in the LI (Hammer et al., 2009; Højen & Bleses, 2023).

These contrasting findings might be explained by the differences in the quality of the home language environment (Golinkoff et al., 2019; Hammer et al., 2014). Research has shown that multilingual children that used the LI less frequently at home still demonstrated strongest LI skills when they were exposed to high-quality language experiences at home, characterized by a good home literacy environment and high levels of parental education (Bratlie et al., 2025).

Among Peers

Peers play an important role in a child's development, as language learning and other cognitive skills depend on social interaction with others. Højen and Bleses (2023), analyzing national test data of a large sample of bilingual children, found that using the LI with friends significantly predicted LI language comprehension in second grade, whereas language use with parents did not. This may reflect the importance of peer input in the LI or indicate a higher level of assimilation among children who predominantly use the LI with peers. However, the influence of peer language can vary based on factors such as the quality of peer language, intensity of contact, and individual child characteristics (Chen et al., 2020). Dünkel and colleagues report that the peer language influenced multilingual adolescents' language reading scores and conclude "peer group predictors are rather small, nevertheless they add value for explaining bilingual language outcomes when controlling for relevant predictors" (2024, p. 2).

In Media

Children today not only experience language in contact with other people, but also via a wide range of media, as they are born into increasingly technologized environments (Flewitt et al., 2024; Kieninger et al., 2023). The availability of child-oriented content—such as audiobooks accessible through screen-free audio players, children’s videos on internet platforms and streaming services, as well as digital games and educational apps—has increased considerably in recent decades (Feierabend et al., 2024). In multilingual families, this media exposure often spans multiple languages (Cycyk & De Anda, 2021; Flewitt et al., 2024). Given

these relatively recent developments in children's media and technology use, there is currently a lack of research investigating how the language of media consumption relates to language and early literacy skills in the LI, particularly among multilingual children. However, some early findings hint towards a potential link: for example, media use in a specific language has been associated with language learning in older children, i.e., fourth graders (Kuppens, 2010).

In Preschool

Early childhood education and care (ECEC) from the age of three, e.g., preschool, has long been identified as a key measure to provide all children, irrespective of family background, with a conducive learning environment to boost educational development (Melhuish et al., 2015; OECD, 2025). PISA results, for example, indicated a difference between preschool attenders and non-attenders in reading scores at age 15 that was roughly equivalent to the impact of one year of schooling (OECD, 2011). High quality in preschool, which encompasses developmentally appropriate curricula and warm, responsive language interactions with adult caregivers, has been shown to have modest but positive associations with children's language and literacy development (see meta-analyses for the United States, Soliday Hong et al., 2019; and Europe, Ulferts et al., 2019).

Multilingual students particularly benefit from attending preschool as early and rich experiences with the LI ahead of school entry constitute an essential prerequisite to acquiring school-related literacy skills (Byers-Heinlein & Lew-Williams, 2013; Gogolin & Neumann, 2009). This is supported by a large-scale study in the United States, which found especially large differences in language and early literacy skills at age five between attenders and non-attenders of pre-K when they were bilingual (Ansari et al., 2021). The ECEC settings in this study had a high population of multilingual children—56 % of the children spoke a language other than English at home—and included support for multilingual families, such as help lines in various languages.

Preschool effects on multilingual students also depend on the quality of the language environment. A high interaction quality in ECEC is especially crucial for the development of multilingual students' LI (Willard et al., 2021), as language learners need engaging and responsive communication partners that use rich vocabulary and complex sentence structures (Hoff, 2006b). Additionally, research has shown that multilingual children benefit from teachers using language structures more adapted to those learning a new language; i.e. shorter sentences—an effect not observed in monolingual peers (Bowers & Vasilyeva, 2011).

8.1.3 Media Use in Childhood

Even independent of the language used in media, the quantity and quality of media experiences might affect language and literacy development (Højen et al., 2021). In a review of experimental studies, no differences were found between the amount learned from different media types, from viewing to reading or listening to the radio (Gowenlock et al., 2024). However, other studies indeed show that different types of media have different effects on language and literacy development (Kostyrka-Allchorne et al., 2017; Valcárcel Jiménez et al., 2024). Thus, the role of exposure to different media on language and literacy is explored in more detail below.

Reading

Frequent shared reading practices have been associated with higher early language and literacy skills in the LI (Noble et al., 2019; Parpucu & Ezmeci, 2024; Valcárcel Jiménez et al., 2024), but also long-term reading comprehension and skills (Mol & Bus, 2011). This is no surprise as reading books together with young children constitutes a language interaction in which adults and children engage in conversations about the visual contents, characters and plot of a book. They can also discuss print elements such as letter symbols or the directionality in reading (Orellana et al., 2025). Researchers have found that during shared reading, a) parents exhibit more sophisticated language in vocabulary and syntactic diversity (Anderson et al.,

2021; Ece Demir-Lira et al., 2019), and b) children are exposed to new words, which might increase their vocabulary (Harris et al., 2011). Findings even support the notion of an "upward spiral of causality" where stronger readers read more (Van Bergen et al., 2018), and the higher print exposure improves their advantage in literacy and language even more (Mol & Bus, 2011).

Frequent shared reading is thus part of a supportive home literacy environment (Wirth et al., 2022), next to other aspects such as literacy exposure (number of owned books) and shared linguistic activities such as singing or rhyming.

Benefits of shared reading and parental literacy practices have also been underlined for bilingual learners (Fitton et al., 2018). The frequency of shared reading in the LI has been shown to predict children's language outcomes in that language (Kalia, 2007; Patterson, 2002). However, even independent of the language of shared book reading, beneficial effects of home literacy practices on language and literacy skills in the LI have been identified. For example, the home literacy environment was the only significant predictor of decoding skills and one of the significant predictors of language skills in a Danish study on multilingual children (Højen & Bleses, 2023), irrespective of the type of bilingualism or parents' LI skills. A similar association between the home learning environment and early language and literacy skills was also found for younger children in preschool when entry into childcare was controlled for (Højen et al., 2021). However, a meta-analysis found that associations between the home literacy environment and instructional language outcomes in bilingual learners was only moderate, smaller than the large associations that have been found for monolingual learners (Dong & Chow, 2022).

Watching Videos

Based on the definition of Geerts, who defines television and online video as "audiovisual content intended to entertain, inform, enrich or involve viewers, is or was

distributed via a telecommunications channel and is being watched on a screen-based device" (2009, p. 9), we use "video exposure" throughout this paper broadly to refer to linear television, streaming content and internet videos. Research has shown mixed results regarding the impact of television and online video exposure on language and literacy development (Kostyrka-Allchorne et al., 2017; Madigan et al., 2020). These inconsistencies are partly due to differences in *study design.* A scoping review on the association between video exposure and language skills found that quasi-experimental cross-sectional or longitudinal studies mostly yielded negative or null relationships, while experimental studies, particularly those examining the transfer of specific language features, often report positive effects after carefully controlled viewing sessions (Gowenlock et al., 2024).

Not only the study design, but also *what and how* children watch, affects the results. Watching high-quality educational content increased children's basic language and literacy skills, such as vocabulary and decoding skills, in some studies. In contrast, watching adult-directed or violent content was found to be detrimental to various developmental outcomes (Kostyrka-Allchorne et al., 2017; Madigan et al., 2020). As these quality indicators often were confounded with family background, controlling for socioeconomic status (SES) often diminished the previously observed associations between video viewing and language skills (Blankson et al., 2015; Schmidt & Anderson, 2007).

Studies involving bilingual children have produced mixed findings. For instance, Patterson et al. (2002) reported no significant impact of video exposure on bilingual children's vocabularies in either Spanish or English. In contrast, Valcárcel Jiménez et al. (2024) found a significant negative effect of video exposure on phonological awareness, letter knowledge, and vocabulary in the LI (German) in a diverse sample that included both mono- and multilingual children. Again, the adverse association may be attributed to particular aspects of video exposure, such as content type or viewing context. Hudon et al. (2013) found that factors such

as an early start to viewing, exposure to inappropriate content, solitary viewing, and background television were all associated with lower vocabulary scores in bilingual toddlers, whereas the overall amount of viewing was not.

While causality could not be firmly established in the cited literature due to methodological limitations, the evidence suggests that the frequency of video exposure is either negatively associated or unrelated to early language and literacy skills for both mono- and multilingual children. These effects might stem from video watching taking the place of more cognitively engaging activities, such as reading, or from its influence on attention and arousal pathways (Shin, 2004).

Listening to Audio

Research on the impact of audio media exposure on language and literacy development is sparse. A review including learners of all ages argued that listening to music should be beneficial for second language learning but could not present much solid empirical evidence on it (Lee & Schreibeis, 2022). A review by Best (2020) also finds little empirical research on audiobook effects on literacy development in monolingual contexts and concludes that listening to audiobooks might lead to higher motivation and text comprehension for older children. Another review looked at the effects of audiobook listening and print reading on comprehension performance (Singh & Alexander, 2022). They found that younger children and multilingual children might especially benefit from involving audiobooks in the classroom. However, none of the listed studies examined the effects of audio media exposure at *home* in young multilingual populations.

8.2 Present Study

In the current study, we sought to determine how exposure to the LI and exposure to different media were associated with listening comprehension and early literacy skills in the

LI. In particular, we investigated this for children of different home language groups in a diverse multilingual cohort of Luxembourgish first graders.

The research questions that guide the study are:

(1) How does the language environment and media exposure at home differ for distinct home language groups in multilingual Luxembourg?
(2) Is exposure to the LI at home positively associated with Luxembourgish listening comprehension (LLC) and early literacy skills in the LI for both mono- and multilingual children, even when media exposure and child background factors are controlled for?
(3) Is attendance in voluntary preschool positively associated with LLC and early literacy skills in the LI for both mono- and multilingual children, even when language and media exposure as well as child background factors are controlled for?
(4) Is exposure to media, i.e., books, video, and audio, associated with LLC and early literacy skills in the LI for both mono- and multilingual children, even when language exposure and child background factors are controlled for?

The role of language exposure at home was investigated exploratively, as previous papers found mixed results on this topic: either a significant association of LI exposure with language, but not early literacy outcomes in the LI (Højen & Bleses, 2023), no significant effects of LI exposure on language and literacy outcomes in the LI after taking the home learning environment into account (Bratlie et al., 2025; Hammer et al., 2009), or positive associations between exposure to the LI and language outcomes in the LI (Scheele et al., 2010; Thordardottir, 2019). Based on previous findings (Ansari et al., 2021; Melhuish et al., 2015), preschool attendance, which constitutes a further context in which the LI is experienced, is expected to positively predict both listening comprehension and early literacy in all home language groups, with stronger associations for children not speaking the LI at home.

Similar to Højen and Bleses' (2023) finding that a high frequency of book reading explained variance in second-grade language comprehension and early literacy beyond children's language use and parental language skills in the LI, we hypothesize that book exposure positively predicts listening comprehension and early literacy skills in the LI, independently of language exposure. The role of video and audio exposure was investigated in an exploratory manner, as this more digital side of the home learning environment has not been investigated yet in a multilingual sample while controlling language exposure to the LI.

Results of our quantitative large-scale study in Luxembourg might provide insights into ways that children's language and literacy acquisition can be supported at home in both monolingual and multilingual family contexts. The broad and partly explorative findings of this study tentatively achieve this aim and offer promising avenues for future research.

8.3 Method

8.3.1 General Information on Luxembourg's Setting

Luxembourg has one of the highest student migration rates among OECD countries (United Nations, 2020), reflected by the fact that 43.5% of the elementary school population does not hold the Luxembourgish nationality (MENJE & SCRIPT, 2024). This demographic diversity is mirrored in the country's exceptional linguistic landscape. With three historically rooted national languages—Luxembourgish, German, and French—Luxembourg also hosts a wide array of other home languages spoken by students, including Portuguese, English, Slavic languages, or many others. In 2024, fewer than one-third of students reported Luxembourgish as their first home language (MENJE & SCRIPT, 2024), a proportion that has been steadily declining over the past decades (MENJE, 2017).

In line with the multilingual composition of the student population, educational settings in Luxembourg are also inherently multilingual. The national languages are introduced

progressively as LI within the public school system. Luxembourgish—alongside French since 2017—is promoted in ECEC (Service National de la Jeunesse, 2018). From Grade 1 onward, German becomes the primary language for formal schooling and literacy development. French is taught orally as a second language in Grade 1 and gradually assumes a role as a medium of instruction in later school years.

Luxembourg offers a diverse, highly subsidized, and well-attended ECEC system, comprising various services and providers. Prior to entering formal schooling in Grade 1 at age 6, all children attend two years of mandatory preschool, referred to as *Cycle 1*. Preceding this, children may attend a year in voluntary preschool, known as *précoce*, for no cost between the ages of three and four. Although attendance is not compulsory, it remains popular, with 72% of children enrolled in 2021 (Hornung et al., 2023).

The pedagogical approach for both voluntary and mandatory preschool is outlined in the Code of Education for early and preschool education (European Commission, 2023). Preschool aims to foster school readiness by promoting oral skills in Luxembourgish, early mathematical reasoning, environmental exploration, psychomotor development, creative expression, and social-emotional skills and values (MENJE, 2018). These three preschool years constitute the formal component of ECEC in Luxembourg and are integrated into the public school system (Honig & Haag, 2011). Informal ECEC is available for children from the age of three months and includes settings such as childcare centers, parental assistants, and other after-school care services. In some cases, these services are used in parallel to formal ECEC attendance (Bollig et al., 2016).

In terms of staffing, teachers in mandatory preschool are required to hold a bachelor's degree in educational sciences. In voluntary preschool, a qualified teacher with a bachelor's degree works in tandem with a caregiver who has completed vocational training (Meisch, 2025a).

Although Luxembourgish and German are essential for students' academic development as early LI, they are not the predominant languages used in broader society, where French is often employed in professional and administrative contexts. Therefore, we refer to Luxembourgish and German as LI rather than majority or dominant languages.

8.3.2 Procedure

This study draws on data from Luxembourg's national school monitoring programme, Épreuves Standardisées (ÉpStan). Administered at the start of each new learning cycle—every two years in Grades 1, 3, 5, 7, and 9—ÉpStan assesses students' academic competencies in core subjects such as mathematics and languages across the public school system (comprising 196 schools). The programme provides valuable insights for teachers, educators, and policymakers. For this study, data were collected in November 2023 in Grade 1. Teachers were provided with detailed instructions and paper-based test materials to assess students' academic performance in the classroom. Additionally, questionnaires were distributed to both parents and students to gather contextual information on family background and other relevant variables. Participation in ÉpStan is mandatory for all public schools in Luxembourg.

Ethical approval for the secondary data analysis of ÉpStan data was obtained from the Ethics Advisory Committee of the University of Luxembourg (ERP 25-094 SecDA ÉpStan). The ÉpStan themselves are based on Luxembourgish legislation and adhere to the APA Ethical Principles (American Psychological Association, 2017). They are approved by the national committee for data protection, and analyses were performed with an anonymized dataset to comply with the European Data Protection Regulation.

8.3.3 Participants

The observational, cross-sectional data (N = 5,929) in this study included all students participating in ÉpStan 2023 in first grade for whom more than administrative data was

available (which had removed 8 students from the original datase) and who did not attend an international public school (which had removed 403 students from the dataset). The sample included circa 48% girls and had a mean age of 6.38 years (*SD* = 0.51).

The age range of 5 to 9 years goes back to 216 students who had repeated at least one year of mandatory preschool. This number is quite high as grade retention in Luxembourg is referred to as *Allongement de Cycle*, a term introduced following a 2009 reform aimed at reducing both the frequency and stigma associated with repeating a grade. The school system is structured into two-year learning cycles, which may be extended to a third year if students have not yet achieved the expected core competencies by the end of the second year (OEJQS, 2024b).

The sample had an average score of 50.98 on the HISEI (Index of highest parental occupation status) scale (ranged 16.25–69.90), and 45% spoke the LI with at least one parent. More descriptive statistics for all variables can be found in Table 10.

8.3.4 Variables

Academic performance was assessed via standardized tests based on the national curriculum. The tests were developed by a multidisciplinary team of scientists and elementary school teachers, peer-reviewed, and thoroughly pre-tested. The resulting scores were based on Weighted Likelihood Estimation (WLE) person parameter estimates from dichotomous Rasch models.

Table 10. *Descriptive statistics*

	n	*% miss.*	*M*	*SD*	min	max	skew	kurtosis
Performance								
LLC	5,724	3.46	512.30	111.28	41.11	792.43	-0.04	0.17
Early literacy	5,680	4.20	519.51	133.03	-8.87	822.55	0.17	-0.20
Language environment								
Contexts LI	5,444	8.18	4.17	2.69	0.00	10.00	0.16	-1.07
Preschool (1 = yes)	3,798	35.94	0.95	0.22	0.00	1.00	-4.04	14.32
Media frequency								
Book freq.	5,004	15.60	4.34	0.90	1.00	5.00	-1.50	2.02
Video freq.	5,032	15.13	4.36	0.74	1.00	5.00	-1.27	2.27
Audio freq.	5,017	15.38	4.33	0.91	1.00	5.00	-1.54	2.20
Control variables								
SES	5,165	12.89	50.98	16.37	16.25	69.90	-0.40	-1.17
Age	5,904	0.42	6.38	0.51	5.00	9.00	0.75	-0.66
Gender (1 = female)	5,922	0.12	0.48	0.50	0.00	1.00	0.06	-2.00
Home Language Group								
MonoLI	1,593	4.99	0.28	0.45	0.00	1.00	0.96	-1.07
MultiLI	931	4.99	0.17	0.37	0.00	1.00	1.80	1.25
NonLI	3,109	4.99	0.55	0.50	0.00	1.00	-0.21	-1.96

Note. N = 5,929. LLC = Luxembourgish Listening Comprehension; LI = language of instruction; SES = socioeconomic status; MonoLI = only speaking LI with parents, MultiLI = speaking LI and at least one other language with parents, NonLI = not speaking LI with parents.

Luxembourgish Listening Comprehension (LLC)

LLC items tested receptive understanding of vocabulary and syntax as well as the comprehension of texts on everyday topics such as family, school, and animals. Contents and instructions were presented in Luxembourgish on an audio streaming platform. The test duration was approximately 35 minutes. The resulting scale was Rasch-scaled to a mean of 500 and a standard deviation of 100, as well as anchored to the previous cohorts. The WLE reliability for the LLC test in 2023 was .82.

Early Literacy

The standardized test on early literacy tested phonological awareness and visual discrimination skills, the understanding of the alphabetic principle, as well as syllable and word reading and writing. Test instructions were presented in Luxembourgish on an audio streaming platform, and the test booklet content (i.e., words) were presented in German. The test duration was approximately 30 minutes. The ÉpStan scores were Rasch-scaled to a mean of 500 and a standard deviation of 100 and also anchored to the previous cohorts. The WLE reliability for the early literacy test in 2023 was .88.

Home Language Group

Information on students' home language use was gathered through a student questionnaire, in which first-grade students were asked to indicate the language they most frequently spoke with their mother and father (or legal guardians), respectively. The questionnaire was administered by teachers in Luxembourgish. Based on the responses, students were categorized into three language groups: (1) MonoLI—students who spoke only the LI (Luxembourgish or German) at home; (2) MultiLI—students who spoke Luxembourgish or German along with at least one additional language at home; and (3) NonLI—students who spoke one or more languages at home that did not include Luxembourgish or German.

Language Exposure at Home

The language exposure at home was assessed through the parent questionnaire using a matrix that included five distinct contexts: language use within the family, with peers, through audiobooks/audio plays/songs, through told or read stories, and through movies or videos. For each context, parents could indicate regular contact with up to six languages: Luxembourgish, French, German, English, Portuguese, and Other. Multiple selections per context were allowed. Exposure to the LI at home was operationalized as the total number of contexts in which the

child was in contact with Luxembourgish and/or German. This resulted in a composite score ranging from 0 to 10, referred to as 'Contexts LI' in all subsequent tables.

Media Exposure

Parents indicated in the parent questionnaire how frequently their child engaged with different types of media. Responses were recorded using a five-point scale: 'nearly every day', 'once or twice a week', 'two or three times a month', 'once a month or more rarely', and 'never'. Media exposure was assessed across three media categories: *books* (including both read-aloud and told stories), *video* (including movies and videos), and *audio* (including audiobooks, audio plays, and songs).

Preschool Attendance

Parents indicated in the parent questionnaire if their child had attended the voluntary preschool year, *précoce,* at age 3, prior to entering mandatory preschool, *Cycle 1*, at age 4, and was thus exposed to Luxembourgish in this additional context. In the following, we refer specifically to the voluntary preschool year when using the term preschool. Attendance differed slightly between home language groups, with attendance rates of 96 % in the MonoLI group, 97 % in the MultiLI group, and 94 % of the NonLI group.

Background Variables

We included SES, age, and gender as control variables since these variables can be related to both the predictor and outcome variables.

Socioeconomic Status (SES)

SES was assessed using the HISEI scale, which reflects the highest occupational status among parents. HISEI is based on the International Socio-Economic Index of Occupational Status (ISEI; Ganzeboom, 2010). Parents reported their occupation by selecting the corresponding top-level International Standard Classification of Occupations (ISCO) category (ILO, 2012), with examples of common occupations in Luxembourg provided for reference.

Average ISEI scores for each occupational category were derived from Luxembourg-specific data from the Programme for International Student Assessment (PISA), calculated separately for mothers and fathers. Higher ISEI values indicate higher parental SES.

Age

Students' age was determined by subtracting their year of birth, obtained from administrative records, from the assessment year (2023).

Gender

Gender information was primarily obtained from administrative records. In cases where this data was unavailable, self-reported information provided by the students was used instead.

8.3.5 Data Analyses

For research question 1, differences in the language environment and media exposure between different home language groups were investigated descriptively. For our research questions 2 to 3.1, we conducted subgroup analyses via six multiple linear regressions—one for each combination of the three home language groups and the two outcome variables (LLC and early literacy). Each regression analysis included exposure to LI at home, preschool attendance, exposure to books, video, and audio as main predictors. As family and student background variables were significantly associated with outcome and predictor variables (see Table 11), we included them as control variables in the linear regression analyses. The study utilized a between-subjects design for all analyses.

To deal with missing data in our linear regressions (see Table 10 and Appendix A3.1 for information on missingness), we employed multiple imputation by chained equations (MICE). Twenty imputed datasets were generated using predictive mean matching for continuous variables and binary variables (see Austin & Van Buuren, 2023), and polytomous logistic regression for categorical variables. All variables included in the analyses were also incorporated into the imputation model, with the exception of the 'Contexts LI' sum score,

which was computed after the imputation process. Supplemental analyses on missing data in our sample show that children with lower early literacy scores had slightly more missing data on other variables. They also indicate that potential comprehension problems with the language of the questionnaire may explain some of the missing data. Therefore, questionnaire language and match with home language were included as auxiliary variables in the imputation (see Appendix A3.1). Other auxiliary variables used in the imputation included German listening comprehension scores in Grade 1, migration background, and single-item indicators of language use across different contexts.

Regression analyses were performed on each dataset separately, and results were pooled using Rubin's rules. Imputation and analysis were performed in R using the mice package (Buuren & Groothuis-Oudshoorn, 2024). We did not exclude outliers, as all values were deemed plausible.

As students were nested in classes and school, independence of observations could not be assumed. The Intraclass Correlation Coefficient (ICC) coefficient based on the variance components of a non-imputed null model indicated that out of the total variance in early literacy, 12% was located at the school level and 6% at the class level. For LLC, 15 % of the total variance was located at the school level and 5 % at the class level. To avoid skewed estimates, regressions were performed using cluster robust SE's for the school level with the function lm.cluster() from the R package miceadds (Robitzsch & Grund, 2025).

The prerequisites of regression analysis were tested using the non-imputed dataset for each home language group. For both outcome variables, visual inspections via histogram and Quantile–Quantile (Q–Q) plot indicated that a group of students had reached the maximum test score (see Figures A3.2 and A.3.3 in the Appendix) as the test was designed to test the minimum competency level of the previous school years.

Table 11. *Correlation table*

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12
1. LLC	512.30	111.28												
2. Early literacy	519.51	133.03	.58** [.56, .60]											
3. Contexts LI	4.17	2.69	.44** [.42, .46]	.24** [.21, .26]										
4. Preschool (1 = yes)	0.95	0.22	.06** [.03, .09]	.02 [-.02, .05]	.06** [.03, .09]									
5. Book frequency	4.34	0.90	.32** [.30, .35]	.22** [.19, .24]	.23** [.20, .26]	.01 [-.02, .05]								
6. Video frequency	4.36	0.74	.05** [.02, .08]	-.03* [-.06, -.00]	.07** [.04, .10]	-.02 [-.05, .01]	.03* [.00, .06]							
7. Audio frequency	4.33	0.91	.16** [.13, .18]	.09** [.06, .12]	.17** [.14, .20]	.03 [-.01, .06]	.27** [.24, .29]	.13** [.11, .16]						
8. SES	50.98	16.37	.37** [.34, .39]	.34** [.31, .36]	.17** [.14, .20]	-.07** [-.10, -.03]	.31** [.28, .33]	-.00 [-.03, .03]	.09** [.06, .11]					
9. Age	6.38	0.51	-.03* [-.06, -.00]	-.02 [-.05, .00]	-.05** [-.08, -.03]	.03 [-.00, .06]	-.07** [-.09, -.04]	.02 [-.01, .05]	-.00 [-.03, .03]	-.10** [-.13, -.07]				
10. Gender (1 = female)	0.48	0.50	.08** [.06, .11]	.09** [.07, .12]	.04** [.01, .06]	-.01 [-.04, .02]	.02 [-.00, .05]	.00 [-.03, .03]	.06** [.03, .09]	.01 [-.02, .03]	-.05** [-.07, -.02]			
11. HL (1 = MonoLI)	0.28	0.45	.43** [.41, .46]	.20** [.18, .23]	.58** [.56, .60]	.03* [.00, .07]	.20** [.17, .22]	.10** [.08, .13]	.15** [.12, .18]	.15** [.13, .18]	-.03* [-.05, -.00]	.01 [-.01, .04]		
12. HL (1 = MultiLI)	0.17	0.37	.03* [.00, .06]	.03* [.01, .06]	.11** [.08, .14]	.03* [.00, .07]	.02 [-.01, .04]	-.01 [-.03, .02]	-.03 [-.06, .00]	.03* [.00, .06]	-.02 [-.05, .00]	.00 [-.03, .03]	-.28** [-.30, -.26]	
13. HL (1 = NonLI)	0.55	0.50	-.42** [-.44, -.40]	-.21** [-.23, -.18]	-.61** [-.63, -.60]	-.06** [-.09, -.02]	-.19** [-.22, -.16]	-.09** [-.12, -.06]	-.12** [-.14, -.09]	-.16** [-.19, -.14]	.04** [.02, .07]	-.01 [-.04, .01]	-.70** [-.71, -.68]	-.49** [-.51, -.47]

Note. Unimputed dataset with listwise missing deletion. *M* = mean, *SD* = standard deviation; LLC = Luxembourgish Listening Comprehension; LI = Language of Instruction; HL = Home Language; MonoLI = speaking the language of instruction at home; MultiLI = speaking the language of instructional and another language at home; NonLI = not speaking the language of instruction at home. Values in square brackets indicate the 95% confidence interval for each correlation. *$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

This extreme group was characterized by high percentage of native (61–79%), Luxembourgish/German-speaking (67–84%) students from high-SES families (41–48% in the highest SES quantile). The dependent variables thus deviate slightly from a normal distribution toward a bimodal distribution. However, skewness and kurtosis values were within commonly suggested cutoff criteria (Byrne, 2011; H.-Y. Kim, 2013). Multicollinearity of predictors was not an issue, as indicated by the variance inflation factor (VIF < 2). Homoscedasticity and normality of residuals were checked by visual inspections and the Breusch-Pagan test. Visual inspections support the normality and homoscedasticity of residuals for both LLC and early literacy. However, for the MonoLI and the NonLI group, the Breusch-Pagan test ($p < .05$) indicated heteroscedasticity for the LLC models. We addressed this by using heteroscedasticity-robust and cluster-robust standard errors (Cameron & Miller, 2015).

For all statistical tests, an alpha level of .05 was used. We report standardized coefficients and unstandardized coefficients to facilitate interpretation and ensure comparability. However, the comparability of standardized coefficients is approached with caution, as these coefficients are influenced by sample variability and study-specific characteristics (Goldstein-Greenwood, 2023). Therefore, interpretations are made carefully and within the context of these limitations. The effect size was indicated by the standardized coefficients in the linear regression. Effects are cautiously interpreted based on Gignac and Szodorai's guidelines (2016), where r = .10 indicates small effects, r = .30 medium effects, and r = .50 large effects.

Besides the already mentioned packages, our analyses used R version 4.4.1 (R Core Team, 2024a) and RStudio version 2024.09.0.375 with the packages apatable (Stanley, 2023), car (Fox et al., 2024), flextable (Gohel & Skintzos, 2024), ggmice (Oberman, 2023), ggpubr (Kassambara, 2023a), gt (Iannone et al., 2023), gtsummary (Sjoberg et al., 2025), moments (Komsta & Novomestky, 2022), naniar (Tierney et al., 2024), officer (Gohel et al., 2024),

performance (Lüdecke et al., 2021), psych (Revelle, 2023), rmarkdown (Allaire et al., 2023), sjPlot (Lüdecke, 2023), stats (R Core Team, 2024b), texreg (Leifeld & Zucca, 2024), and tidyverse (Wickham, 2023).

8.3.6 Transparency and Openness

We report how we determined our sample size, all data exclusions, and all manipulations in the study. The R scripts for the analyses are publicly available at https://doi.org/10.17605/OSF.IO/SJRGK. We acknowledge the use of Microsoft's Copilot (2025) for linguistic refinement and grammar editing and Perplexity AI (2025) as a search engine for coding and statistics queries. All external suggestions were reviewed and, where appropriate, cross-referenced before being integrated. The authors take full responsibility for the contents presented in this article.

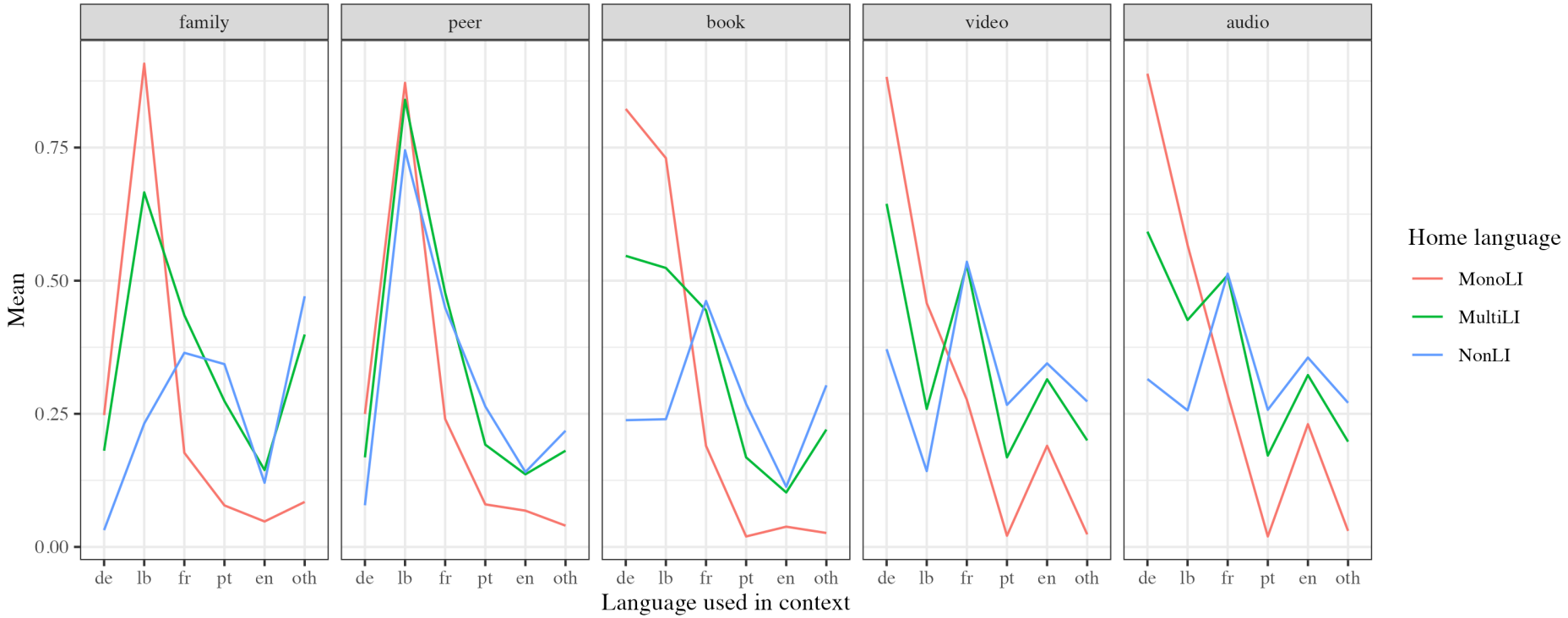
8.4 Results

8.4.1 Descriptive Differences in Home Environment Between Language Groups

As illustrated in Figure 21, language exposure across contexts varied notably depending on the language group to which a child belonged (see Figure A3.4 in the Appendix for full sample figure). Students were grouped based on whether they spoke the instructional languages—Luxembourgish and German—with their parents. A consistent pattern emerged in the peer context: all groups were predominantly exposed to Luxembourgish as the lingua franca among friends.

The MonoLI group, which spoke only the instructional languages at home, reported high exposure to Luxembourgish across all contexts (46%–91%) and common engagement with German-language media (82%–89%). Other languages were reported less often (< 25%), with the exception of French, which was reported by 28–29% in video and audio contexts.

Figure 21. *Descriptive plot of language use in different contexts, split by home language group*



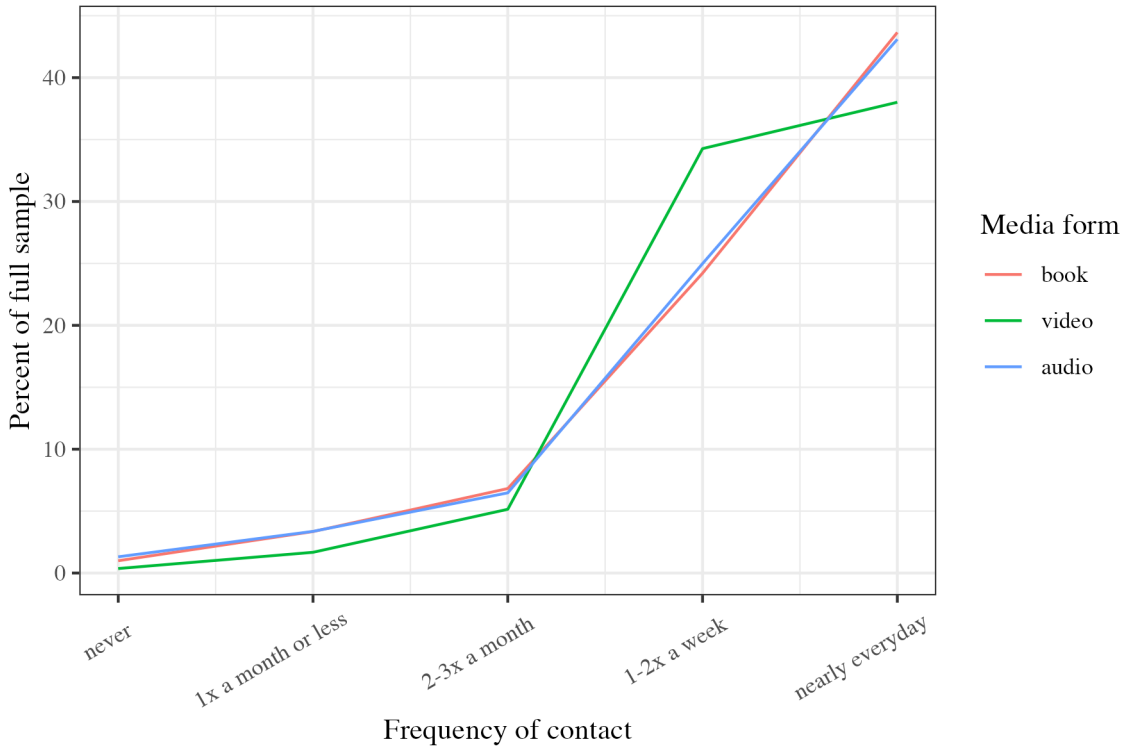
Note. Graph shows the percentage of the home language group that was reported to be in contact with a language in a respective context. de = German; lb = Luxembourgish; fr = French; pt = Portuguese; en = English; oth = other language; MonoLI = speaking only the languages of instruction with their parents; MultiLI = speaking the language(s) of instruction and another language with their parents; NonLI = not speaking the languages of instruction with their parents.

The MultiLI group, which spoke both instructional and additional languages at home, showed similar patterns, but lower exposure to Luxembourgish and German than the MonoLI group (66% reported Luxembourgish in the family, 54–63 % reported German in media). This group showed greater similarity to the NonLI group in their exposure to French, English, Portuguese, and other languages. French was particularly prominent in the MultiLI group, appearing in all media types (45–53%), in the family (43%), and among peers (48%). Additionally, 40% of MultiLI parents reported that their child was in contact with other, unspecified languages at home.

The NonLI group, which did not speak the instructional languages at home, reported the lowest exposure to Luxembourgish and German (23% reported Luxembourgish in the family, 24–37 % reported German in media). Instead, French, Portuguese, and other languages were most frequently spoken in the family (32–48%). Media use in this group was dominated by French (51–53%) and English (38–39%), although German media was also accessed by a notable proportion (e.g., 34% watched German videos or movies). Across all media types, each language was reported by more than 12% of NonLI students, indicating a high degree of linguistic diversity in the group.

As illustrated in Figure 22, media use frequency among children showed strong ceiling effects across all three media types—books, video, and audio. A substantial proportion of the sample (40–47%) reported that their children engaged with each medium nearly every day. This trend was slightly less pronounced for video, where 37% of respondents indicated that their child used video media once or twice a week. Across all media types, fewer than 10% of participants selected any of the lower frequency options, suggesting that the upper end of the conservative frequency scale may have been insufficient to capture the full range of media contact in Grade 1.

Figure 22. *Descriptive plot of the frequency of media use*



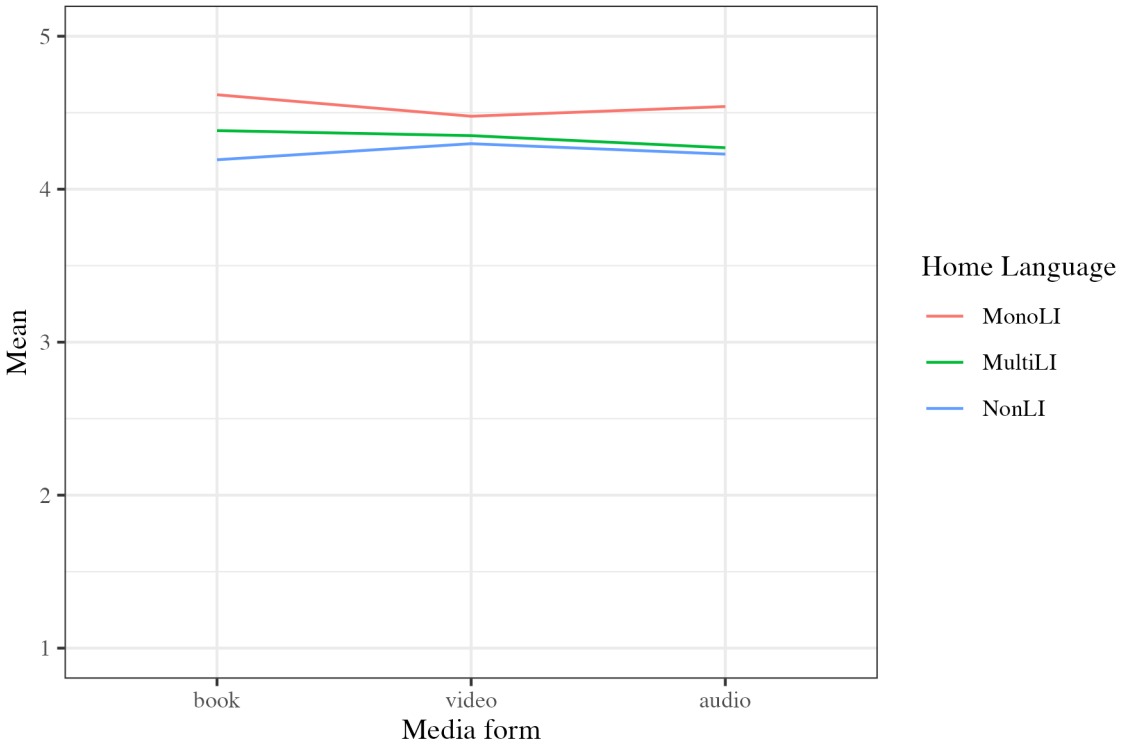
Note. Graph shows the percentage of the sample that was reported to engage with a type of media in a respective frequency.

Figure 23 presents descriptive differences in media use frequency across home language groups. Overall, the average frequency of media use was similar among the three groups, ranging between 4 ('once or twice a week') and 5 ('nearly every day') on the scale. The MonoLI group reported slightly higher average media use, while the NonLI group showed slightly lower frequencies. Given the minimal variation between groups and across media types, further breakdowns by media form are not reported.

8.4.2 Associations with LLC by Home Language Group

The full results of the linear regression on LLC for the different home language groups are presented in Table 12 (see Table A3.5 in the Appendix for analysis on the full sample). Focal results are described here.

Figure 23. *Descriptive plot of the frequency of media use, split by home language group*



Note. Graph shows the average frequency of media use of each home language group. MonoLI = speaking only the languages of instruction with their parents; MultiLI = speaking the language(s) of instruction and another language with their parents; NonLI = not speaking the languages of instruction with their parents.

The number of contexts in which the child was in contact with LI significantly predicted LLC for all home language groups (b = 6.71 to 12.34, p < .001). Each additional LI context was associated with an approximately 7-point increase in LLC scores for the MonoLI and NonLI group and with an approximately 12-point increase for the MultiLI group. Preschool attendance only showed a significant association with LLC for the NonLI group (b = 36.34, p < .001). NonLI children that had attended preschool scored about 36 points higher in the LLC test than those who did not. For all home language groups, book frequency was a significant predictor of LLC (b = 16.03 to 24.14, p < .001), while video frequency did not significantly predict LLC (b = -2.03 to 6.25, p > .05). Audio frequency was a significant predictor for the MonoLI group who had slightly higher LLC scores with higher frequency of audio exposure (b = 10.37, p < .05).

Table 12. *Linear regression analysis with Luxembourgish listening comprehension as outcome, split by home language group*

	MonoLI		MultiLI		NonLI	
	***b* (*SE*)**	**β (*SE*)**	***b* (*SE*)**	**β (*SE*)**	***b* (*SE*)**	**β (*SE*)**
(Intercept)	198.64*** (40.49)	0.41 (0.04)	150.38* (62.31)	-0.04 (0.03)	267.48*** (29.09)	-0.22 (0.02)
Contexts LI	6.97*** (1.41)	0.17 (0.03)	12.34*** (1.68)	0.30 (0.04)	6.71*** (0.78)	0.16 (0.02)
Preschool (1 = yes)	13.4 (13.18)	0.03 (0.03)	29.05 (19.40)	0.06 (0.04)	36.34*** (7.66)	0.08 (0.02)
Book frequency	18.20*** (3.80)	0.15 (0.03)	24.14*** (4.91)	0.20 (0.04)	16.03*** (1.84)	0.13 (0.02)
Video frequency	3.39 (3.87)	0.02 (0.03)	6.25 (5.11)	0.04 (0.03)	-2.03 (2.27)	-0.01 (0.02)
Audio frequency	10.37* (4.08)	0.09 (0.03)	3.41 (4.13)	0.03 (0.03)	-0.87 (1.85)	-0.01 (0.02)
SES	1.64*** (0.17)	0.24 (0.03)	1.86*** (0.22)	0.28 (0.03)	1.63*** (0.12)	0.24 (0.02)
Age	14.22** (4.67)	0.07 (0.02)	4.71 (7.46)	0.02 (0.03)	1.67 (3.33)	0.01 (0.02)
Gender (1 = female)	10.20* (4.36)	0.05 (0.02)	16.17* (6.61)	0.07 (0.03)	16.97*** (3.22)	0.08 (0.01)

Note. N = 5,929 split into N_{MonoLI_pooled} = 1,658, $N_{MultiLI\_pooled}$ = 966, N_{NonLI_pooled} = 3,305. LI = language of instruction; SES = socioeconomic status; *SE* = standard error; *CI* = 95%-confidence interval for *b*. * p < .05. ** p < .01, *** p > .001.

8.4.3 Associations with Early Literacy by Home Language Group

The result of the linear regression on early literacy for the different home language groups is presented in Table 13 (see Table A3.6 in the Appendix for analysis on the full sample).

In all home language groups, early literacy was significantly predicted by the number of contexts in which the child was in contact with LI (b = 4.27 to 10.79, p < .01). An additional LI context was associated with an approximately 5-point increase in early literacy skills for children in the Mono -and NonLI groups.

Table 13. *Linear regression analysis with early literacy as outcome, split by home language group*

	MonoLI		**MultiLI**		**NonLI**	
	***b* (*SE*)**	**β (*SE*)**	***b* (*SE*)**	**β (*SE*)**	***b* (*SE*)**	**β (*SE*)**
(Intercept)	312.54*** (58.05)	0.11 (0.04)	261.48** (75.01)	0.00 (0.03)	288.49*** (36.06)	-0.09 (0.02)
Contexts LI	5.29** (1.75)	0.11 (0.04)	10.79*** (1.84)	0.22 (0.04)	4.27*** (1.04)	0.09 (0.02)
Preschool (1 = yes)	-6.73 (16.71)	-0.01 (0.03)	11.64 (23.62)	0.02 (0.04)	20.75* (8.85)	0.04 (0.02)
Book frequency	18.36** (5.30)	0.13 (0.04)	11.18 (6.37)	0.08 (0.04)	13.87*** (2.46)	0.10 (0.02)
Video frequency	-9.42* (4.75)	-0.05 (0.03)	-9.23 (6.25)	-0.05 (0.04)	-8.16** (2.91)	-0.05 (0.02)
Audio frequency	4.37 (4.97)	0.03 (0.04)	1.31 (4.53)	0.01 (0.03)	0.33 (2.34)	0.00 (0.02)
SES	2.35*** (0.22)	0.29 (0.03)	2.27*** (0.32)	0.28 (0.04)	2.14*** (0.14)	0.27 (0.02)
Age	2.77 (6.47)	0.01 (0.03)	10.21 (9.41)	0.04 (0.04)	5.82 (4.48)	0.02 (0.02)
Gender (1 = female)	24.42*** (6.11)	0.09 (0.02)	16.60 (8.63)	0.06 (0.03)	21.61*** (4.18)	0.08 (0.02]

Note. N = 5,929 split into N_{MonoLI_pooled} = 1,658, $N_{MultiLI\_pooled}$ = 966, N_{NonLI_pooled} = 3,305. LI = language of instruction; SES = socioeconomic status; *SE* = standard error; *CI* = 95%-confidence interval for *b*. *p < .05. **p < .01, ***p > .001.

For MultiLI, the association was doubled with an 11-point increase in early literacy skills for each additional LI context. The association between preschool attendance and early literacy was only significant for NonLI children. For them, preschool attendance had a small positive association with early literacy (b = 20.75, p < .05), which means that preschool attenders scored about 20 points higher than non-attenders in that home language group.

Book frequency was only a significant predictor of early literacy for Mono- and NonLI children (b = 13.87 to 18.36, p < .01). This association was positive, with higher early literacy at a higher frequency of book exposure. In contrast, the frequency of video media use was negatively associated with early literacy, but this association was only significant for MonoLI and NonLI children (b = -8.16 to -.42, p < .05). Audio frequency did not significantly predict early literacy skills for either home language group (b = 0.33 to 4.37, p > .05.

8.4.4 Additional Explorative Analyses on Preschool Attendance

To investigate the role of SES in the preschool effects further, we conducted additional interaction analyses (see Tables A3.7 and A3.8 in the Appendix), testing whether SES moderated the association between preschool attendance and the two outcome variables, LLC and early literacy. Only in the MonoLI group, SES significantly moderated the association between preschool attendance and LLC (b = -2.58, p < .01), indicating that children with lower SES in the MonoLI group benefitted more in LLC than those with higher SES. No such moderation effects were found in other home language groups or for early literacy.

8.5 Discussion

The present study examined whether exposure to the LI at home and in preschool, as well as exposure to media, were independently associated with listening comprehension and early literacy skills in the LI for mono- and multilingual children, taking into account the SES and background factors of the child.

8.5.1 Exposure to LI at Home and Preschool Attendance

In regard to our first research question, exposure to the LI in more contexts was positively associated with listening comprehension and early literacy skills in the LI for mono- and multilingual children, even when media exposure and child background factors were controlled for. This explorative finding is in line with results from Thordardottir (2019) who found that the amount of exposure to each language in simultaneous and sequential bilingual children predicted their language skills (vocabulary and word structure) in the respective language. In contrast to our study, Thordardottir assessed language exposure in greater detail, using comprehensive parent reports that captured exposure in hours across various contexts. Participants were grouped based on the percentage of their waking hours spent in environments where the target language was spoken. Taken together, these findings indicate that the

relationship between LI exposure and language skills seems to hold both with broader and narrower operationalizations of language exposure.

As outlined in the literature review, some previous studies on bilingual children have not found a similar effect of increased LI exposure at home on language or literacy outcomes when controlling for aspects of the home learning environment (Bratlie et al., 2025; Hammer et al., 2009; Højen & Bleses, 2023). This suggests that our inclusion of SES and media exposure may not have fully captured the complexity of the home learning environment. Additional aspects of the home learning environment, such as parental resources and engagement in learning activities, might need to be included to find a similar suppression effect.

Interestingly, an additional context in which the LI was spoken had the descriptively strongest relationship with LLC and early literacy for the MultiLI group, that is, children that spoke both Luxembourgish/German and another language with their parents. Even though our home language variable did not directly assess native speaker status, it is likely that many parents who primarily speak Luxembourgish with their children are native speakers. For children in this group, increased exposure to the LI across multiple contexts may therefore reflect more frequent interactions with native speakers, which has been shown to be particularly beneficial for bilingual language development (Place & Hoff, 2011).

Notably, exposure to the LI was still significant for the MonoLI group, i.e., children who only spoke the LI (Luxembourgish and/or German) with their parents. MonoLI families who place a high value on education may make deliberate efforts to ensure their children also come in contact with German—the subsequent language of literacy instruction— from an early age through books and audio media, often corresponding to a more formal, school-related register. Such a close alignment between children's language and literacy practices at home and the linguistic and literacy expectations of the school environment is likely to facilitate a smoother transition into formal education and academic success (Heath, 1983; Hornberger,

2003; Olson, 2016). Parental efforts to expose children to German may also reflect broader characteristics of the home learning environment, such as its overall quality or the parents' educational background and values, as well as their knowledge of the school system. These factors could support children's early academic skills through multiple pathways beyond language exposure alone.

Given the significant association between LI contexts and language and literacy skills in the NonLI group, it would be valuable to further investigate which specific context—ranging from family and peers to media—had the strongest impact. It is plausible that NonLI children—whose parents were likely non-native speakers of the LI—benefited most from exposure to the LI through peer interactions or media sources. Potentially, language interaction with siblings may also play a role here, as a Luxembourgish study finds Luxembourgish was the most commonly spoken language between siblings (38–61 %), even in early childhood (Service National de la Jeunesse, 2023).

In regard to *preschool attendance*, results were mixed. First, preschool attendance was more beneficial for LLC than for early literacy skills. This finding aligns with the curriculum of the voluntary preschool year for children aged 3 to 4 in Luxembourg, which places a strong emphasis on developing Luxembourgish language skills. The primary goal of this early educational stage is to ensure that all children acquire sufficient proficiency in Luxembourgish to begin formal schooling successfully.

Preschool attendance was also only significantly beneficial for one home language group—NonLI, which had the least exposure to LI at home. This is in line with previous research on childcare effects in Luxembourg (Kaufmann, Ottenbacher, et al., 2025), finding early childcare only beneficial for the listening comprehension of NonLI children, as well as international findings on preschool effects. For example, Ansari et al. (2021) found that multilingual children benefited more strongly from pre-K attendance in different academic

outcomes, including vocabulary and letter word identification at age 5, than English-only speakers in the United States. For multilingual children, preschool may offer valuable opportunities to interact and communicate with consistent language models in the LI (Hoff, 2006b)—opportunities which their parents might not be able to provide at home.

In contrast, children already speaking the LI at home (MonoLI and MultiLI) did not significantly benefit from preschool attendance. This indicates that the language these children spoke and heard at home when not attending preschool might have been similarly beneficial for them as the preschool language environment. Possibly, the Luxembourgish spoken in preschool might have been more oriented towards those starting to learn Luxembourgish. As such, the language level and hence language input may have not been sufficiently adapted for all children in MonoLI and MultiLI groups to further profit from attending preschool in their LLC and early literacy.

Exploring the role of SES in this relationship, additional preliminary interaction analyses (see Tables A3.7 and A3.8 in the Appendix) revealed that within the MonoLI group, children from low-SES backgrounds benefited significantly more from preschool attendance in their LLC scores than high-SES peers. Thus, for the MonoLI group, preschool attendance only seemed to play a role for children from lower-SES families, which is often correlated with fewer school-related practices in the home learning environment (Hoff, 2006a; Vasilyeva, 2011). No such SES-related differences were observed for early literacy or within the MultiLI and NonLI groups. This suggests that for MultiLI and NonLI groups, exposure to the LI in preschool is crucial, independent of SES.

8.5.2 Exposure to Media

In regard to our second research question, media exposure effects on listening comprehension and early literacy skills in the LI strongly depended on media type and home language group.

The frequency of *book reading and storytelling* was positively associated with both listening comprehension and early literacy in the LI across home language groups, while controlling for background factors such as SES and language exposure at home. This is in line with a wealth of literature, pointing towards the exceptional impact of print exposure, shared reading experiences, and the overall importance of a high-quality home literacy environment (Mol & Bus, 2011; Niklas & Schneider, 2017; Parpucu & Ezmeci, 2024; Sénéchal & LeFevre, 2002). MonoLI and NonLI children seemed to benefit similarly strong from book exposure in their language and early literacy skills. This can be explained by the fact that shared reading and book exposure not only increase the exposure to symbols, letters, and print, but also represent an interactive oral moment between parent and child. In these interactions, parents tend to use more sophisticated vocabulary and syntactically diverse language than in everyday life (Anderson et al., 2021; Ece Demir-Lira et al., 2019; Harris et al., 2011) and ask more questions than in toy play (Kirkpatrick, 2003; Salo et al., 2016). In contrast, the MultiLI group (i.e., simultaneous bilinguals) seemed to benefit more strongly from book exposure in LLC, but weaker in early literacy. The reasons for this discrepancy remain unclear.

Notably, children in the NonLI group significantly benefited from book frequency in language and literacy in the LI, even though the specific language of the shared book reading was not recorded, and language exposure was controlled for. This result indicates that book reading was beneficial to them, regardless of the language of reading. This association might be mediated by print exposure which helps increase the familiarity with and knowledge of letters as well as metalinguistic competencies such as directionality of reading, etc. (Orellana et al., 2025; Wesseling et al., 2017). Additionally, the written language in children's books provides exposure to a more formal, school-related register of language, which is what is required in school and literacy acquisition (Olson, 2016; Schleppegrell, 2001). Alternatively, increased home language skills due to reading activities in the home language may also support

the acquisition of the LI in school (linguistic interdependence theory, see Cummins, 1979; Edele et al., 2023).

Video frequency was not significantly correlated with language, but it was linked to lower early literacy skills in the MonoLI and NonLI groups. For the MultiLI group, we observed a similarly sized association between video exposure and early literacy as in the other language groups; however, this association did not reach statistical significance due to a higher standard error for that group. Generally, the negative association of video exposure with literacy skills may stem from the fact that videos typically include language and sound but offer limited exposure to written text. Additionally, the quality of content might vary more strongly for video exposure than for book exposure (Henderson et al., 2024; Kieninger et al., 2023). A common explanation for the negative effects of video exposure is that video viewing replaces reading or other more beneficial activities (displacement effect, see Neuman, 1988; Willson, 2019). However, in our study, the negative impact of video exposure was found even when reading frequency was held constant. Moreover, book and video exposure were positively correlated, albeit with a small effect size. Taken together, our findings do not support the presence of a displacement effect. Nonetheless, it is possible that the ceiling effect of the scale assessing video and book exposure in our study was too strong to give reliable insight into this question.

Audio frequency was mostly unrelated to language and literacy. This is a new finding, as no other studies have yet investigated the role that frequent exposure to audio media (audiobooks, audioplays, and music) plays in language and early literacy skills of first graders. The audio variable in the present study included three different kinds of audio media, each of which may have distinct effects. We suspect that stronger effects might have been found for story-based audio formats with a more formal register, such as audiobooks or plays, as these closely align with the language skills emphasized in school, helping children to develop an

interest in reading and exposing them to new vocabulary (Best, 2020, 2021). Differences may also emerge based on the context of listening to audio media, as children may listen to audio while simultaneously involved in other play activities. Thus, their attention may not always fully lie on the audio medium (Ritterfeld et al., 2005; Varao Sousa et al., 2013). Interestingly, audio exposure was significantly related to LLC in MonoLI children, who showed a slightly higher listening comprehension with more frequent audio exposure. Potentially, this is because this group most likely listens to audio media in Luxembourgish and German, training exactly the skill of comprehending short oral stories that are tested in the LLC test.

8.5.3 Limitations and Outlook

First, our findings on media exposure are limited by the fact that the used frequency scale for media exposure was too conservative for the actual media use of the sample. Thus, the response distribution became strongly lopsided, with around 40 % of parents picking the highest response ("nearly everyday"). This ceiling effect has prevented us from checking for a quadratic effect of video exposure. Such a quadratic effect had been previously found in regard to language (Dore et al., 2020), where moderate exposure to electronic media—approximately 30 hours per week—was associated with the greatest vocabulary gains. Using the scale of Dore and colleagues (2020), where parents indicated media use for different categories in hours on a typical school day (0–1, 2–3, 4–5, 6–7, and 8+ h), could have been helpful in getting closer to a normal distribution of reading, viewing and listening frequencies. Furthermore, the exposure scale might have been improved by assessing each subcategory of media separately. For example, we suspect different effects of storytelling and book reading on language in multilingual children, similar to the results of Scheele and colleagues (2010). They found that reading and storytelling have similar correlations with the vocabulary of monolingual children, but only storytelling was correlated with vocabulary in bilingual children. In contrast, Law et al. (2018) reported stronger effects of book reading at age 5 than storytelling at age 5 on verbal

knowledge at age 11 in a representative sample without language background information. Thus, it might be interesting to consider storytelling and book reading as two separate variables of literacy activities in future studies on language group differences.

Second, as in many other cross-sectional studies, potential moderators and mediators of the media and language exposure effects were not included in this study. To determine the necessary conditions of language and media exposure that promote language and literacy in mono- and multilingual children, more information on the specific home learning and language environment would need to be collected. This was not feasible in the context of the present full-cohort large-scale study, as questionnaire extensions underlie strict time-efficiency considerations aimed at maximizing sample retention (Sharma, 2022). However, follow-up studies could consider including a more detailed assessment of the HLLE, including variables that cover the availability of literacy resources, parental involvement and beliefs, as well as the balance of language use at home. This would allow for a more nuanced investigation of how ECEC attendance interacts with the home environment. Furthermore, more detailed information on language and media exposure, such as age of onset, context of exposure, and content quality, could be assessed in a smaller study via questionnaires, interviews, or the e-diary method (Kostyrka-Allchorne et al., 2017; Schulz & Grimm, 2019), to further unravel the relationship of language and media exposure with literacy acquisition.

Fourth, there might have been impacts of the pandemic on the results of this study, limiting the transferability to other cohorts. As our cohort (first graders in 2023) would have attended childcare and/or early preschool during the lockdown periods, experiences in ECEC might have been different than those in non-pandemic years. However, a UK study indicated that childcare attendance was beneficial for all children's language and cognitive development even during the pandemic, with stronger effects on language for less advantaged children

(Davies et al., 2021). Additionally, attendance rates of early preschool in Luxembourg did not appear to have declined due to the pandemic (cf., Hornung et al., 2023).

Fifth and last, this paper did not assess the home language or heritage language skills of multilingual children, as this was not the focus of this paper. We acknowledge that home language skills are also important for children's long-term outcomes, for example, wellbeing, and quality of relationships (Tseng & Fuligni, 2000). Especially in Luxembourg, where different languages are spoken in various aspects of daily life, bi- and multilingualism can come with unique social and professional benefits (Bialystok, 2009; Luxembourg Government, 2025).

8.5.4 Implications

The present study highlights that not only do experiences in ECEC or school shape children's journey to literacy, but parents' decisions and activities in early childhood also have an important impact on the early language and literacy development of their children.

Most importantly, the positive effects of book exposure, independent of the language group and exposure, should empower caretakers to practice shared reading with children to support their emergent literacy in a fun and effective way. This is an important finding, especially now, when children are increasingly exposed to digital media (Feierabend et al., 2024; Kucker et al., 2024). Similarly, the mixed, but mostly non-significant effects of video and audio exposure should be a reminder that even though language or speech might be present in a digital medium, it might not have the same beneficial effects as real-life interactions or shared reading activities. Content and context of media exposure need to be carefully considered, especially if children are young (Feierabend et al., 2024; Henderson et al., 2024).

Language exposure to the LI also had strong positive effects for the development of language and literacy skills necessary in first grade. Proficiency in the LI and a community's lingua franca is a key determinant for academic success. It represents a "cognitive

competenc[e] with lasting influence on cognitive, sociocognitive and social development" (Ebert et al., 2013, p. 2), particularly through its impact on literacy, which is a fundamental driver of individual and societal development (UNESCO, 2005). While the present non-experimental study does not allow conclusions on interventions or which language parents should speak to their children in different contexts, it does show the importance of ensuring contact with the LI in preschool, at least for multilingual children with little exposure to the LI at home.

All in all, this study represents the first large-scale investigation into these important questions within the highly diverse and multilingual Luxembourgish setting. Future research could build on these results to develop tailored interventions for multilingual contexts. Such efforts would enable parents to better support their multilingual children in navigating the challenges of the demanding education system.

8.6 Conclusions

This study examined exposure to the LI and to different types of media as well as their relationship with listening comprehension and early literacy, in three home language groups of first graders, using large-scale school monitoring data of Luxembourg. Language exposure, but not so much media exposure, differed across language groups. Contact with the LI in more contexts was positively associated with listening comprehension and early literacy across all home language groups, while preschool attendance was only beneficial for higher language and literacy in children not speaking the LI with their parents. Media exposure effects depended on the type of media and home language group, with mostly positive associations for book exposure, null to negative associations for video exposure to mostly non-significant associations for audio exposure. The independent impacts of language and media exposure on both language and early literacy skills in multilingual students underline the important role that

early experiences in the home environment, and thus parents, can play in children's journey towards literacy acquisition.

8.7 Appendix

Appendix A3.1 *Handling missing data*

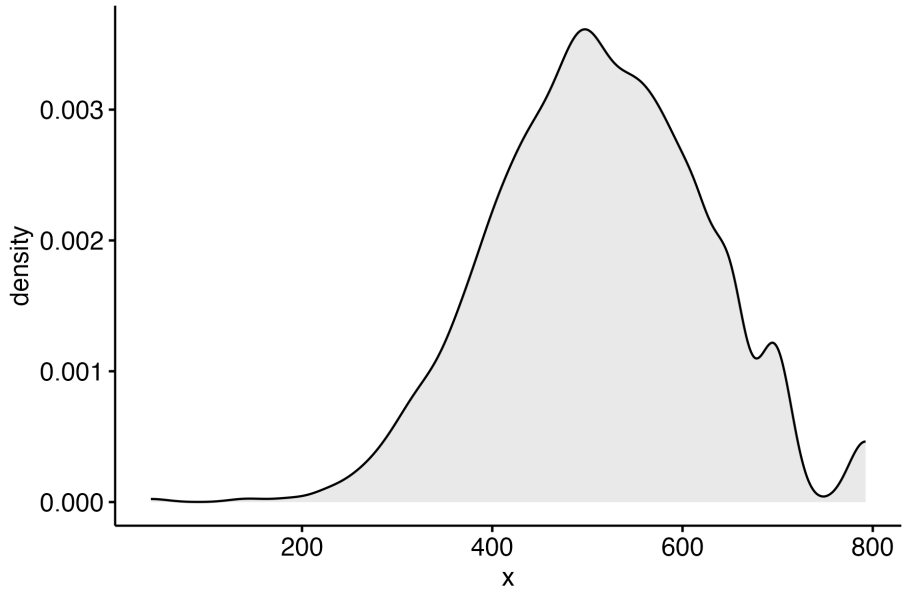
After listwise deletion of missing datapoints, complete information on all variables is available for 3,755 out of 5,929 students. The primary reason for data loss is the preschool variable, which had 36% missing values. However, this remains below the 40% threshold, beyond which multiple imputation is not recommended anymore (Dettori et al., 2018). To see whether MAR can be assumed, we conducted analyses to investigate the missing data. First, we tested whether missingness in our predictor variables could predict LLC and early literacy.

LLC was negatively predicted by missingness in SES, migration background, book frequency, preschool attendance, age ($p > .05$), positively predicted by missingness in the language in context variable ($b = 25.23$, $p < .001$), but not missing values in gender and audio or video frequency ($p > .01$). While missing values in age, gender, audio or video frequency or language in contexts did not significantly predict early literacy ($p > .05$), missingness in SES, migration background, book frequency and preschool attendance was significantly associated with lower early literacy ($p > .01$). This means that our unimputed sample mostly underrepresented children with lower performance. Second, we investigated whether missingness in each predictor variable could be predicted by values in the family background variables or student characteristics. Here, we find a complex pattern of relationships. For example, missingness in the preschool variable was higher for children with lower SES ($b = -.002$, $p > .001$) or those with a first generation migration background ($b = .13$, $p > .001$). Children with a first-generation immigration background were also more likely to have missing data on performance, home language, and socioeconomic background ($b = (-.0004) - (-.04)$, $p > .05$). Furthermore, children speaking other languages than the instructional language with their parents seemed to have more missingness on migration background ($p > .001$). These

patterns suggest that missingness in the parental questionnaire may be due to comprehension problems in the language of the questionnaire.

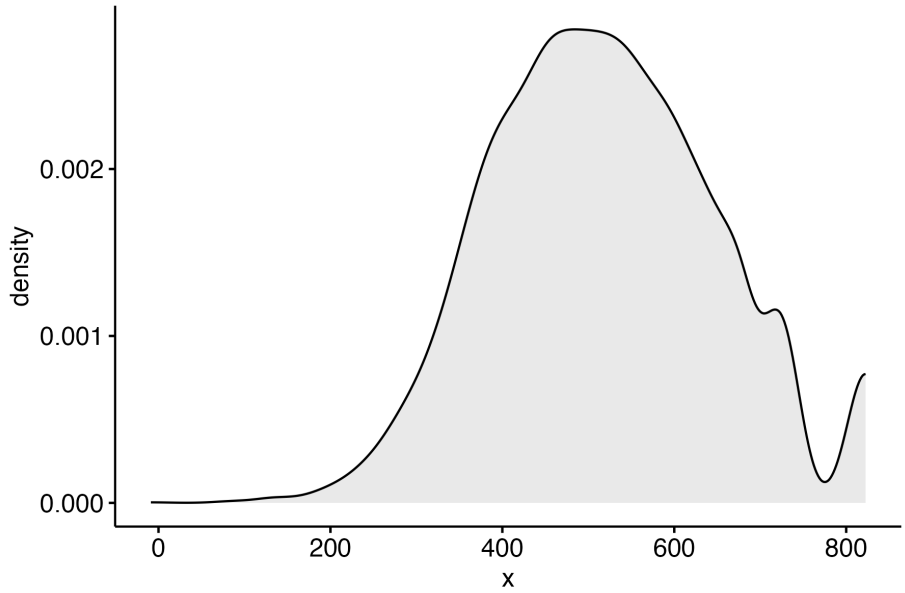
We tested whether parental questionnaire language and the match of questionnaire language to home language can explain missingness in the preschool variable and performance variable. We found that children whose parents filled out the questionnaire in German (rather than French, Portuguese, or English) had higher scores in performance (b = 16.82 - 129.01, p < .01) and lower missingness than some other language groups (b = .02 - .06, p > .05). They also mostly had a higher likelihood of missing data in preschool (b = 0.18 - .28, p < .01) or migration background (b = .36 - .76, p < .05). If parents filled out the questionnaire in one of their home languages, we also found fewer missing data in parent questionnaire variables, e.g. preschool attendance (b = -0.27, p > .001). Due to this, we included both questionnaire language and a variable indicating a match of questionnaire language to home language in the imputation dataset.

Figure A3.2. *Histogram of Luxembourgish listening comprehension*



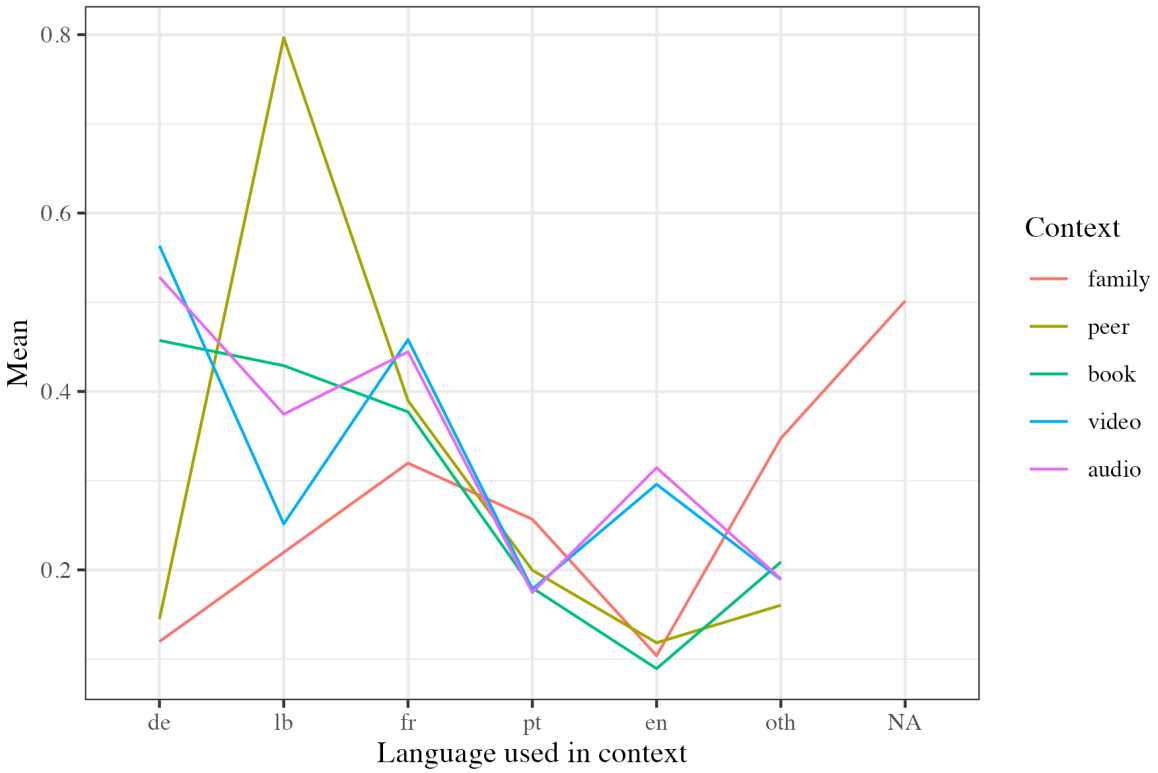
Note. Graph shows the density of the sample for different ÉpStan scores. x = ÉpStan score for Luxembourgish Listening Comprehension.

Figure A3.3. *Histogram of early literacy*



Note. Graph shows the density of the sample for different ÉpStan scores. x = ÉpStan score for early literacy.

Figure A3.4. *Descriptive plot of language use in different contexts.*



Note. Graph shows the percentage of the sample that was reported to be in contact with a language in a respective context. de = German; lb = Luxembourgish; fr = French; pt = Portuguese; en = English; oth = other language.

Table A3.5. *Linear regression analysis with Luxembourgish listening comprehension as outcome*

	b	*SE*	*t*	*p*	95%-*CI*	β
(Intercept)	178.51	22.60	7.90	< 0.001	[133.01; 224.01]	0.00
Contexts LI	14.54	0.49	29.66	< 0.001	[13.57; 15.50]	0.35
Preschool (1 = yes)	34.02	5.79	5.87	< 0.001	[22.56; 45.47]	0.07
Book frequency	18.92	1.70	11.13	< 0.001	[15.52; 22.31]	0.16
Video frequency	2.67	1.99	1.34	0.187	[-1.35; 6.69]	0.02
Audio frequency	2.89	1.52	1.90	0.060	[-0.13; 5.90]	0.02
SES	1.78	0.10	18.32	< 0.001	[1.58; 1.98]	0.26
Age	6.04	2.70	2.24	0.028	[0.68; 11.41]	0.03
Gender (1 = female)	14.42	2.46	5.86	< 0.001	[9.59; 19.25]	0.06

Note. N = 5,929. LI = language of instruction; SES = socioeconomic status; *SE* = standard error; *CI* = 95%-confidence interval for *b*.

Table A3.6. *Linear regression analysis with early literacy as outcome*

	b	*SE*	*t*	*p*	95%-*CI*	β
(Intercept)	270.04	28.85	9.36	< 0.001	[212.37; 327.71]	-0.00
Contexts LI	8.33	0.63	13.32	< 0.001	[7.11; 9.56]	0.17
Preschool (1 = yes)	15.89	7.81	2.04	0.047	[0.19; 31.59]	0.03
Book frequency	14.56	1.98	7.36	< 0.001	[10.68; 18.45]	0.10
Video frequency	-7.83	2.30	-3.41	0.001	[-12.35; -3.31]	-0.04
Audio frequency	1.67	1.93	0.87	0.388	[-2.13; 5.48]	0.01
SES	2.27	0.10	22.07	< 0.001	[2.06; 2.47]	0.28
Age	6.00	3.57	1.68	0.096	[-1.09; 13.08]	0.02
Gender (1 = female)	21.44	3.16	6.77	< 0.001	[15.23; 27.64]	0.08

Note. N = 5,929. LI = language of instruction; SES = socioeconomic status; *SE* = standard error; *CI* = 95%-confidence interval for *b*.

Table A3.7. *Linear regression analysis with Luxembourgish listening comprehension as outcome, split by home language group with interaction term between preschool attendance and SES*

	MonoLI			**MultiLI**			**NonLI**		
	b	***SE***	**95%-*CI***	***b***	***SE***	**95%-*CI***	***b***	***SE***	**95%-*CI***
(Intercept)	55.707	63.629	[-70.253; 181.668]	153.162	100.799	[-63.342; 369.667]	263.297***	31.530	[201.182; 325.413]
Contexts LI	7.071***	1.415	[4.288; 9.854]	12.314***	1.684	[8.978; 15.651]	6.709***	0.784	[5.167; 8.252]
Preschool (1 = yes)	162.358**	53.317	[56.049; 268.667]	26.408	78.917	[-142.115; 194.931]	40.931	21.386	[-1.581; 83.443]
SES	4.149***	0.858	[2.459; 5.840]	1.826	1.406	[-1.198; 4.850]	1.711***	0.426	[0.855; 2.567]
Book frequency	17.516***	3.844	[9.970; 25.061]	24.123***	4.893	[14.217; 34.029]	16.016***	1.843	[12.376; 19.656]
Video frequency	3.339	3.860	[-4.235; 10.913]	6.239	5.127	[-4.142; 16.621]	-2.054	2.276	[-6.579; 2.472]
Audio frequency	10.218*	4.003	[1.804; 18.633]	3.463	4.172	[-5.015; 11.942]	-0.866	1.856	[-4.548; 2.816]
Age	14.419**	4.634	[5.333; 23.505]	4.665	7.446	[-10.238; 19.568]	1.690	3.338	[-4.949; 8.330]
Gender (1 = female)	10.410*	4.331	[1.921; 18.899]	16.250*	6.635	[3.200; 29.300]	16.987***	3.224	[10.651; 23.324]
Preschool X SES	-2.582**	0.885	[-4.331; -0.833]	0.038	1.438	[-3.061; 3.137]	-0.091	0.464	[-1.039; 0.856]

Note. N = 5,929 split into N_{MonoLI_pooled} = 1,658, $N_{MultiLI\_pooled}$ = 966, N_{NonLI_pooled} = 3,305. LI = language of instruction; SES = socioeconomic status; *SE* = standard error; *CI* = 95%-confidence interval for b. * $p < .05$. ** $p < .01$, *** $p > .001$.

Table A3.8. *Linear regression analysis with early literacy as outcome, split by home language group with interaction term between preschool attendance and SES*

	MonoLI			MultiLI			NonLI		
	b	***SE***	**95%-*CI***	***b***	***SE***	**95%-*CI***	***b***	***SE***	**95%-*CI***
(Intercept)	207.429*	87.246	[35.097; 379.761]	184.168	115.547	[-52.737; 421.073]	272.928***	43.867	[185.164; 360.692]
Contexts LI	5.357**	1.760	[1.884; 8.831]	10.755***	1.861	[7.095; 14.415]	4.276***	1.040	[2.237; 6.316]
Preschool (1 = yes)	102.656	77.066	[-54.140; 259.452]	93.493	90.860	[-95.253; 282.239]	37.860	31.470	[-27.783; 103.502]
SES	4.196**	1.264	[1.634; 6.758]	3.739*	1.593	[0.407; 7.071]	2.447***	0.551	[1.313; 3.580]
Book frequency	17.877**	5.295	[7.446; 28.308]	11.036	6.373	[-1.902; 23.974]	13.843***	2.466	[8.967; 18.720]
Video frequency	-9.454*	4.745	[-18.766; -0.142]	-8.926	6.252	[-21.265; 3.413]	-8.206**	2.911	[-13.928; -2.483]
Audio frequency	4.228	4.961	[-5.615; 14.070]	1.118	4.502	[-7.708; 9.945]	0.314	2.341	[-4.288; 4.916]
Age	2.950	6.402	[-9.607; 15.507]	10.047	9.374	[-8.422; 28.517]	5.842	4.474	[-2.993; 14.677]
Gender (1 = female)	24.571***	6.112	[12.589; 36.553]	16.038	8.552	[-0.751; 32.827]	21.623***	4.173	[13.443; 29.802]
Preschool X SES	-1.898	1.336	[-4.636; 0.840]	-1.525	1.551	[-4.727; 1.677]	-0.336	0.574	[-1.518; 0.846]

Note. N = 5,929 split into N_{MonoLI_pooled} = 1,658, $N_{MultiLI\_pooled}$ = 966, N_{NonLI_pooled} = 3,305. LI = language of instruction; SES = socioeconomic status; *SE* = standard error; *CI* = 95%-confidence interval for b. * $p < .05$. ** $p < .01$, *** $p > .001$.

Table A3.9. *Details on unstandardized regression analysis with Luxembourgish listening comprehension as outcome for MonoLI*

	b	***SE***	***t***	***p***	**95%-*CI* lower**	**95%-*CI* upper**
(Intercept)	198.64	40.49	4.906	0.000	118.992	278.282
Contexts LI	6.97	1.41	4.963	0.000	4.212	9.737
Preschool (1 = yes)	13.4	13.18	1.016	0.314	-12.995	39.792
Book frequency	18.20	3.80	4.794	0.000	10.750	25.646
Video frequency	3.39	3.87	0.877	0.381	-4.198	10.984
Audio frequency	10.37	4.08	2.540	0.022	1.732	19.003
SES	1.64	0.17	9.831	0.000	1.310	1.973
Age	14.22	4.67	3.047	0.002	5.065	23.369
Gender (1 = female)	10.20	4.36	2.353	0.019	1.704	18.697

Note. N_{pooled} = 1,658. LI = language of instruction; SES = socioeconomic status; *SE* = standard error; *CI* = 95%-confidence interval for *b*.

Table A3.10. *Details on unstandardized regression analysis with Luxembourgish listening comprehension as outcome for MultiLI*

	b	***SE***	***t***	***p***	**95%-*CI* lower**	**95%-*CI* upper**
(Intercept)	150.38	62.31	2.414	0.022	22.858	277.905
Contexts LI	12.34	1.68	7.344	0.000	9.013	15.666
Preschool (1 = yes)	29.05	19.40	1.498	0.138	-9.510	67.609
Book frequency	24.14	4.91	4.921	0.000	14.202	34.069
Video frequency	6.25	5.11	1.224	0.228	-4.073	16.580
Audio frequency	3.41	4.13	0.825	0.415	-4.960	11.771
SES	1.86	0.22	8.501	0.000	1.433	2.293
Age	4.71	7.46	0.631	0.531	-10.240	19.652
Gender (1 = female)	16.17	6.61	2.446	0.015	3.175	29.168

Note. N_{pooled} = 966. LI = language of instruction; SES = socioeconomic status; *SE* = standard error; *CI* = 95%-confidence interval for *b.*

Table A3.11. *Details on unstandardized regression analysis with Luxembourgish listening comprehension as outcome for NonLI*

	b	***SE***	***t***	***p***	**95%-*CI* lower**	**95%-*CI* upper**
(Intercept)	267.48	29.09	9.195	0.000	208.507	326.454
Contexts LI	6.71	0.78	8.567	0.000	5.167	8.246
Preschool (1 = yes)	36.34	7.66	4.745	0.000	20.763	51.918
Book frequency	16.03	1.84	8.699	0.000	12.388	19.665
Video frequency	-2.03	2.27	-0.894	0.374	-6.539	2.481
Audio frequency	-0.87	1.85	-0.467	0.642	-4.543	2.813
SES	1.63	0.12	13.275	0.000	1.376	1.879
Age	1.67	3.33	0.502	0.617	-4.955	8.302
Gender (1 = female)	16.97	3.22	5.266	0.000	10.634	23.299

Note. N_{pooled} = 3,305. LI = language of instruction; SES = socioeconomic status; *SE* = standard error; *CI* = 95%-confidence interval for *b*.

Table A3.12. *Details on unstandardized regression analysis with early literacy as outcome for MonoLI*

	b	***SE***	***t***	***p***	**95%-*CI* lower**	**95%-*CI* upper**
(Intercept)	312.54	58.05	5.384	0.000	198.573	426.507
Contexts LI	5.29	1.75	3.020	0.003	1.835	8.741
Preschool (1 = yes)	-6.73	16.71	-0.403	0.687	-39.627	26.163
Book frequency	18.36	5.30	3.467	0.001	7.925	28.802
Video frequency	-9.42	4.75	-1.984	0.048	-18.739	-0.103
Audio frequency	4.37	4.97	0.879	0.382	-5.497	14.230
SES	2.35	0.22	10.807	0.000	1.924	2.781
Age	2.77	6.47	0.428	0.669	-9.929	15.463
Gender (1 = female)	24.42	6.11	3.995	0.000	12.436	36.397

Note. N_{pooled} = 1,658. LI = language of instruction; SES = socioeconomic status; *SE* = standard error; *CI* = 95%-confidence interval for *b*.

Table A3.13. *Details on unstandardized regression analysis with early literacy as outcome for MultiLI*

	b	***SE***	***t***	***p***	**95%-*CI* lower**	**95%-*CI* upper**
(Intercept)	261.48	75.01	3.486	0.001	112.264	410.689
Contexts LI	10.79	1.84	5.865	0.000	7.178	14.407
Preschool (1 = yes)	11.64	23.62	0.493	0.623	-35.271	58.542
Book frequency	11.18	6.37	1.754	0.088	-1.760	24.112
Video frequency	-9.23	6.25	-1.477	0.141	-21.559	3.100
Audio frequency	1.31	4.53	0.289	0.773	-7.573	10.192
SES	2.27	0.32	7.009	0.000	1.619	2.924
Age	10.21	9.41	1.085	0.279	-8.334	28.748
Gender (1 = female)	16.60	8.63	1.924	0.055	-0.349	33.542

Note. N_{pooled} = 966. LI = language of instruction; SES = socioeconomic status; *SE* = standard error; *CI* = 95%-confidence interval for *b*.

Table A3.14. *Details on unstandardized regression analysis with early literacy as outcome for NonLI*

	b	***SE***	***t***	***p***	**95%-*CI* lower**	**95%-*CI* upper**
(Intercept)	288.49	36.06	7.999	0.000	216.665	360.312
Contexts LI	4.27	1.04	4.112	0.000	2.233	6.305
Preschool (1 = yes)	20.75	8.85	2.345	0.022	3.088	38.402
Book frequency	13.87	2.46	5.628	0.000	8.998	18.744
Video frequency	-8.16	2.91	-2.809	0.005	-13.873	-2.450
Audio frequency	0.33	2.34	0.142	0.887	-4.271	4.934
SES	2.14	0.14	15.455	0.000	1.867	2.411
Age	5.82	4.48	1.300	0.196	-3.023	14.663
Gender (1 = female)	21.61	4.18	5.175	0.000	13.422	29.787

Note. N_{pooled} = 3,305. LI = language of instruction; SES = socioeconomic status; *SE* = standard error; *CI* = 95%-confidence interval for *b*.

9 General Discussion

In light of the role that academic achievement plays for professional qualification, career opportunities, and overall well-being (Chiswick et al., 2003; Clarke et al., 2025; Ritchie & Bates, 2013), it is worrying that academic achievement does not seem to be equally attainable for all children. Instead, it seems to depend on children's family background and their early experiences at home. ECEC has long been in the focus of researchers as a way to offer all children, independent of their background, a supportive and educationally stimulating environment in the crucial early years of life. As challenging and persistent educational disparities have been observed in Luxembourg since the 1980s (Maurer-Hetto et al., 1991), the main aim of the present thesis was to investigate whether ECEC in Luxembourg plays or could play a protective and beneficial role for the academic achievement of the diverse and multilingual student population.

The following section summarises results from the four studies of this doctoral thesis along the five research interests. RI 5 is discussed in conjunction with the other four.

9.1 Summary and Discussion of Results based on Research Interests

RI 1 Attendance in ECEC

In contrast with previous national and international findings of preschool being more highly attended than childcare (Eurostat, 2024; Honig & Haag, 2011), Study 1 showed that a majority of first graders (82%) in Luxembourg in 2021 had attended childcare, while only 71% had attended the voluntary preschool year[20]. This divergence may be due to several factors: 1) the voluntary preschool year for three-year-olds coincides with the final year of childcare eligibility, allowing parents to choose between the two types of ECEC provision, 2) childcare services typically offer full-day coverage and flexible hours, whereas preschools are only

[20] While obligatory preschool attendance (ages 4–6) was not analyzed in the Study, attendance can be assumed to be close to 100%.

required to provide half-day services of 13 hours per week, 3) although preschool is free, the popularity of childcare has risen since the 2009 and 2017 reforms introduced a certain amount of free, government-subsidized hours—a trend also reflected in the findings of Study 1[21].

In terms of dosage, Study 1 finds a generally early attendance in childcare, with attendance intensities being mostly homogeneously distributed from half-day to full-day attendance. This stands in contrast with findings by Ünver et al. (2021), who find stronger attendance rates of younger children when the ECEC system is unitary instead of fragmented. In Luxembourg, the combination of financial pressures stemming from high costs of living, economic advantages of dual incomes, and greater affordability of early childcare since the 2009/2017 reforms may help explain the high rates of early childcare attendance. Thus, despite the split system, Luxembourg's attendance rates of ECEC resemble those of Scandinavian countries more closely than those of more conservative Eastern European countries (Eurostat, 2024).

While Luxembourgish is the most frequently reported language used in childcare settings (> 66% in 2021), findings from Study 1 highlight that many children already experienced multilingual childcare environments prior to the official implementation of the *éducation plurilingue*. Interestingly, even though only a small portion of the sample would have still attended childcare after the program's launch in 2017, there is a clear upward trend of reports of both Luxembourgish and French being spoken in childcare throughout the entire assessment period. This trend might reflect a natural gravitation towards those two national languages in childcare—driven by the linguistic backgrounds of participating children, parental preferences, and available staff[22]—which was then further confirmed and consolidated by the

[21] Generally, reports of ECEC attendance in Study 1 are higher than the reported numbers for the same year in Eurostat (2024), which are based on administrative data. As Study 1 excluded cases with missing parental data, this may have inadvertently excluded more disadvantaged families who did not use ECEC services.
[22] Especially larger, commercial childcare centers employ mostly French-speaking ECEC staff from the neighboring countries France and Belgium (De Moll et al., 2024; Schreyer et al., 2024).

2017 reform (Honig et al., 2013; Kirsch & Aleksić, 2021). However, the upwards trend may also be influenced by the retrospective parental reporting—collected when children were in first grade between 2015 and 2021—which could have been impacted by public debates and increased visibility of *éducation plurilingue* introduced in 2017. This exposure may have primed parents to recall, or assume, that their children's earlier childcare experiences included Luxembourgish and French, even if that was not the case at the time.

Overall, the findings of this thesis illustrate a pattern of high and early participation in various forms of ECEC in Luxembourg, accompanied by multilingual provision of education and care even beyond the 2017 reform.

RI 1 + RI 5 Differences in ECEC Attendance Based on Family Background

While previous studies on only preschool or aggregated ECEC data could not confirm the existence of attendance disparities in Luxembourg, Study 1 observed several differences in ECEC attendance and dosage based on family background.

Children from native and Luxembourgish-speaking families were generally more likely to attend voluntary preschool, while children from more disadvantaged migration and home language groups were more likely to attend early childcare. This could go back to the following reasons: 1) multilingual parents might prefer multilingual ECEC provision for their children, making it easier for parents to communicate with staff and promote the home language of the child (Bollig et al., 2016), 2) parents with less extensive family networks may be unable to adapt to the unflexible service hours of voluntary preschool, while early childcare provides comprehensive ECEC provision including meals and longer, flexible hours (Wall & José, 2004), 3) parents might culturally prefer the play-based style of non-formal ECEC for their children instead of a more formally educative approach in preschool (Gandhi, n.d.). Given that childcare is the ECEC type with comparatively lower governmental funding, lower requirements for staff qualifications, and a less explicit emphasis on educational stimulation

(OECD, 2022b), this pattern may suggest disparities in access to high-quality ECEC based on migration and language background.

Notably, a different pattern shows for SES. Here, more advantaged children were more likely to attend both childcare and preschool and less likely to attend only preschool than more disadvantaged children. When children from high SES families attended childcare, they were also more likely to attend for more years, but fewer hours per week, compared to their peers, a pattern also visible for native children. Taken together, this lets us speculate that parents in native, high-SES families may view out-of-family care less negatively than others and may return to work more quickly, for example, to a part-time work scheme. They might also be able to arrange alternative care next to childcare more easily, resulting in fewer childcare hours per week.

An interesting pattern emerged showing that home language interacts with SES in shaping ECEC attendance: With rising SES, children from Portuguese-speaking families attended childcare for fewer years and more hours. In contrast, children from Luxembourgish-speaking families attended childcare for more years, but fewer hours when SES was higher. This contrast may reflect differences in access to extended-family-care and in employment conditions, such as part-time work or flexible hours, often linked to job sectors (Wall & José, 2004). For example, parents in native, high SES families are more likely to be employed in the education sector, where such flexibility is given, than parents from other backgrounds (Pit-ten Cate et al., 2021).

Study 1 also highlighted the tendency for children to attend childcare centers where languages similar to their home language were spoken. Parents may hesitate to expose their children to a completely new language environment, preferring instead settings that support the first language development of their children and allow for easier communication with staff sharing their language (see Bollig et al., 2016). This preference may support children's

language acquisition in their first tongue and indirectly in the language of instruction according to the interdependence hypothesis (Cummins, 1979), but may also result in reduced exposure to the language of instruction, and thus, slower development in the language of instruction according to the time-on-task hypothesis (Esser, 2009). While empirical support can be found for both hypotheses, the extent to which negative effects of limited exposure are offset by positive effects of cross-linguistic transfer remains unclear and warrants further investigation in the Luxembourgish context (Edele et al., 2023).

RI 2 ECEC and Short-Term Academic Achievement

Over all studies of the present doctoral thesis, at most very small to small positive associations between ECEC attendance and short-term academic achievement could be found in the full sample when controlling for family and child background characteristics. While these small associations generally reached statistical significance, this might be largely due to the sample size and resulting statistical power. The practical relevance of these full-population effects may be more questionable. Nevertheless, the thesis produced valuable insights into differences depending on ECEC type, dosage and measured outcomes.

Benefits of attendance were strongest for obligatory preschool, less strong for voluntary preschool, and weakest for early childcare, as found in direct comparison in Study 1, but also corroborated by the findings in Studies 2 to 4 that each focused on a specific ECEC type. In Study 3, associations between childcare attendance and Grade 1 academic achievement did not reach significance, underlining the small size of the connection between early childcare, mathematics and early literacy. The visible hierarchy of childcare types might be explained by several factors: First, structural quality seems to be higher in formal preschool types in Luxembourg, which is important to enable process quality and effective learning in ECEC (OECD, 2022b; Slot, 2018). Second, while the alignment between preschool and primary

school is relatively high, the alignment and coordination between early childcare and preschool is not (OEJQS, 2025; Shuey et al., 2019). Alignment and seamless transitions between educational environments are, however, crucial to sustain ECEC benefits (Bailey et al., 2017; Stipek et al., 2017). Last but not least, early childcare might involve fewer explicit instructional activities for mathematics and early literacy than preschool, thus, the higher similarity of input and outcome may explain the higher associations for preschool.

Listening comprehension emerged as the most consistently affected outcome across all types of ECEC. This was particularly evident for early childcare, which did not show a strong link to achievement in mathematics and early literacy in both Study 1 and 3. The association between early childcare and listening comprehension was generally stronger, however, it was slightly smaller in Study 2 (b = 8.08, SE = 3.51) than in Study 1 (b = 19.04, SE = 8.29). This may go back to a difference in reference groups, given that Study 2 did not differentiate between preschool attenders and non-attenders. Obligatory preschool attendance was more beneficial for listening comprehension and mathematics than early literacy. Voluntary preschool, in contrast, was linked to higher scores in listening comprehension and early literacy in Study 1, but in a later cohort (Study 4), its benefits were primarly seen in listening comprehension. Next to cohort differences, this inconsistency between the two studies might also be due to differences in the analytical method and controlled variables. It makes sense that the ECEC system in Luxembourg, which devotes considerable attention to early language learning in ECEC (Government of Luxembourg, 2014; MENJE et al., 2021) would see the strongest benefits of ECEC in the language domain. Additionally, a large proportion of students in Luxembourg do not speak Luxembourgish at home, which lowers the baseline language proficiency in the language of instruction compared to other countries. This could further explain why benefits of ECEC attendance may be particularly pronounced in this domain.

In regard to dosage, Study 1 only found inconsistent patterns of small associations between both duration and intensity of childcare and academic achievement. These unclear patterns may go back to moderating effects of family background characteristics (see next paragraph), and curvilinear relationships which were explored in Study 2 and 3. While Study 3 did not find a curvilinear association between childcare duration and first-grade mathematics or early literacy, Study 2 suggests such a pattern may exist for listening comprehension, with the highest scores observed among children who attended childcare for one to three years, depending on the home language. As provision by preschool and childcare settings overlap for three-year olds, this curvilinear effect may be explained in two main ways. On the one hand, it may reflect the benefits of a later start in out-of-family care, as a substantial body of research argues against ECEC attendance of under one-year-olds given to their heightened vulnerability and need for high quality care (Bensel & Haug-Schnabel, 2018; Fort et al., 2016; Kottelenberg & Lehrer, 2014). On the other hand, it may indicate that children "max out" the benefits of childcare provision at a certain point and would benefit from an early transition to the next educational setting—voluntary preschool—where they are grouped with same age peers in a more stimulating and challenging learning environment (W. Li et al., 2020; Wasik & Snell, 2019). This would be in line with findings of Li et al.(2020) and Soliday Hong et al. (2023) who found that early starting ages were connected to more positive outcomes, while a longer duration was instead connected to weaker effects of ECEC.

RI 2 + RI 5 Differences by Family Background for Short-Term Achievement

How much children benefited from ECEC depended crucially on their background. While the literature indicates that disadvantaged children benefit most from ECEC and especially high-quality ECEC (Bennett, 2012; Melhuish, 2004), findings from the four studies of this thesis show that patterns also deviate depending on which dimension of disadvantage is explored, SES or home language.

For instance, children from high-SES families seemed to benefit more strongly from attending preschool (with or without childcare) than children from low-SES families in Study 1. For students from low-SES families, attending preschool instead of childcare was not associated with higher scores than attending only childcare. This concerning trend of already advantaged high-SES students benefiting more strongly from ECEC was echoed in Study 3. In particular, children from higher-SES families showed stronger associations between childcare attendance and mathematics. Such a Matthew effect is relatively uncommon, as international research typically shows the opposite trend, with disadvantaged students benefiting more from ECEC attendance (Bennett, 2012; Burger, 2010). The finding may go back to disparities in the quality of provision or classroom effects. Families with low SES have been found to have difficulties accessing high-quality provision (Mathers & Smees, 2014; OECD, 2025), and may have fewer resources (time, money, connections) to make sure their children attend childcare centers with high-quality care. A high concentration of disadvantaged children in childcare centers located in lower-income communities might also contribute to less favorable childcare effects for this group, mirroring findings of lower ECEC benefits for targeted instead of universal ECEC provision (Bennett, 2012; Cascio, 2019; de Haan et al., 2013).

In regard to home language, children who did not speak Luxembourgish and/or German benefited more strongly from ECEC attendance. This pattern was consistent with the majority of international literature (Ansari et al., 2021; Kohl et al., 2019; Pion & Lipsey, 2021; Soliday Hong et al., 2023; Yazejian et al., 2015) and seemed remarkably consistent over the four studies. Due to its detailed differentiation of eight home language groups, Study 1 provided quite a complex picture of differences between home language subgroups, indicating that for example, children from Portuguese-speaking families benefited most strongly from higher childcare intensity. Additionally, students speaking South Slavic languages—who represented a relatively small portion of the sample—deviated most strongly from the patterns of other

home language groups[23]. Studies 2 to 4, which operated with a broader, coarse grained home language variable to ease the interpretation of results, found that children who do not speak Luxembourgish and/or German at home had more positive or less negative associations between ECEC attendance and academic achievement. Thus, early childcare and voluntary preschool seem to offer a supportive environment and opportunities for multilingual children to hear and speak the language of instruction, Luxembourgish, with proficient language models (Hoff, 2006b), which is especially critical if parents are not able to provide this at home. In contrast, children who already spoke the languages of instruction, Luxembourgish and/or German, at home did not benefit significantly from childcare, especially when it came to language outcomes. This suggests that for those children, the language environment in early childcare and voluntary preschool might have been similarly beneficial for language skills as the language environment they were provided at home. While previous international studies have shown that monolingual children can also benefit language-wise from ECEC, the language environment in Luxembourg's settings may have been more tailored to language learners, given the large proportion of multilingual children. As a result, the language environment in ECEC may have not been sufficiently challenging to promote the language development of Luxembourgish-speaking children beyond what was provided by parental or other forms of non-center care.

However, an explorative analysis in Study 4 indicates that the pattern of who benefits might be even more fine-grained when considering the intersection of SES and home language. Within the group that speaks only Luxembourgish and/or German at home, children from low-SES families seemed to benefit more from voluntary preschool than those from high-SES families. In contrast, within the groups that also speak other languages at home, children

[23] Specifically, they showed mostly non-significant benefits of ECEC attendance across different ECEC types which may be attributed to substantial within-group variation visible in the standard errors.

seemed benefit from voluntary preschool with no significant differences based on SES. Thus, the language environment at home—a factor highly correlated with SES (Golinkoff et al., 2019)—seems to play a role in ECEC language benefits especially if the language of instruction is spoken at home.

All in all, ECEC reduced but did not close the achievement gap between children of different home language groups. For example, only about 20%[24] of the language gap between home language groups was closed by early childcare in Study 2 (see Figure 12). This shows that the Luxembourgish ECEC system could be one of the tools to alleviate the educational disparities between different students, however, it may not be sufficient to reach this goal in its current effectiveness.

RI 3 ECEC and Long-Term Academic Achievement

Long-term outcomes of ECEC, in particular, early childcare from age 0 to 4, were the focus of Study 3. In general, only an inconsistent pattern of small to very small associations could be found between childcare attendance and academic achievement from third to fifth grade, both in positive and in negative directions. For the full sample, academic achievement and grade retention did not differ significantly between childcare attenders and non-attenders. However, averaged across all children, more years in childcare were associated with lower reading comprehension in third grade and higher grade retention rates between first and fifth grade, potentially indicating advantages in starting childcare later or leaving childcare early to attend preschool.

These findings together indicate that childcare attendance in Luxembourg, averaged across all children, did not show the positive long-term associations with academic

[24] Comparing the coefficients for home language and childcare effects in Table 4, holding all other factors constant.

achievement that have been demonstrated internationally, after initially benefiting Luxembourgish listening comprehension in first grade. Such positive longitudinal academic impacts have been demonstrated in ECEC systems such as Denmark (Esping-Andersen et al., 2012), where high-quality, homogenous care was provided in unitary settings between birth and primary school age. While Luxembourg already invests heavily into ECEC provision (OECD, 2022b), the system it funds might not be the most effective. In the split, highly privatized, and so far unmonitored early childcare system of Luxembourg, quality of provision can only be assumed to be heterogeneous beyond baseline quality requirements (OECD, 2022b), similar to ECEC systems in Australia and the United States that also were not able to produce lasting impacts on academic achievement beyond early grades (Esping-Andersen et al., 2012; Little et al., 2020).

Another point that may have contributed to weak longitudinal associations with mathematics and reading comprehension, is the missing alignment in language curricula between ECEC and primary school. The transition from promoting Luxembourgish in ECEC to instructing and fostering literacy acquisition in German at age six is rooted in the assumption that Luxembourgish serves as a bridge to acquiring skills in German, given their close linguistic relationship (MENJE, 2020). However, more and more research indicates that such a transfer may not work as well for children who do not speak Luxembourgish at home (Hoffmann et al., 2018; Kaufmann et al., 2023), suggesting that benefits of ECEC may get lost in the transition from one to the other language in a form of "conversion loss".

RI 3 + RI 5 Differences by Family Background for Long-Term Achievement

While long-term associations were small and inconsistent when averaged across the full sample, a slightly more consistent pattern emerged when including differential effects by family background. Two main findings emerged across outcomes.

Firstly, socioeconomic status again counterintuitively moderated the relationship between childcare attendance and some indicators of long-term academic achievement. Children from higher-SES families tended to benefit more strongly from childcare attendance in their Grade 3 reading comprehension and and more strongly from a longer duration in childcare in their grade retention rates than children from lower-SES families. Figure 20 illustrates this relationship, showing that grade retention rates for children with medium and high SES are slightly decreased with a longer duration in childcare. However, children in the lowest SES bracket (the lowest 2.1%) show a tendency towards increased probabilities of grade retention with longer duration of childcare attendance, especially at a duration of four years. Again, the unexpected Matthew effect raises questions on the correlation between quality of attended ECEC and SES. If children from low-SES families are indeed found to attend ECEC with lower-quality care in Luxembourg, it would be interesting to see whether whether this is due to individual, local quality differences or more systematic differences between regions, attended ECEC types, or providers.

Secondly, home language moderated the relationship between childcare attendance and academic achievement in certain outcomes. Children not speaking Luxembourgish and/or German at home, benefited from attendance in their fifth-grade mathematics and were not negatively impacted in third-grade reading, while children who spoke Luxembourgish and/or German at home showed no benefits or even negative associations with those outcomes. The moderation was particularly visible in grade retention rates, where childcare attendance reduced the gap between home language groups by 75%. As can be seen in Figure 18, children from average-SES families that speak Luxembourgish/German at home had a grade retention probability of ca. 17% with or without attending childcare. Children from average-SES families that did not speak Luxembourgish/German at home, were estimated to reduce their probability of grade retention from 25% to 19% when attending childcare. This is a substantial reduction.

A similar pattern also emerged for duration, which stood in a curvilinear relationship with grade retention. While more years in childcare were initially associated with a reduced likelihood of grade retention across all groups, a third or fourth year of attendance was linked to a slightly higher probability of grade retention for children speaking Luxembourgish/German at home but not for children who did not speak those languages at home (see Figure 19).

This shows that across the full population, no sustained benefits of childcare were found beyond first grade, while certain subgroups demonstrated continued advantages from childcare attendance up to fifth grade, particularly in terms of a reduced likelihood of grade retention, though not consistently across all academic outcomes. This suggests that for children who learn the language of instruction outside of the family context, it is an advantage to enter informal ECEC early as it may enable a "foot-in-the-door" intervention effect of ECEC (Bailey et al., 2017). This mechanism describes how early interventions may build up children's skills just enough to "sustain individuals through periods of high vulnerability" (p. 21), enabling further positive outcomes due to developmental cascades. As grade retention has been found linked to a series of adverse developmental and academic outcomes (Goos et al., 2021; Jimerson, 2001; Klapproth et al., 2016), preventing children from repeating a school year may well have long-lasting benefits for their academic development.

However, it is concerning that children who spoke Luxembourgish and/or German at home showed lower reading comprehension in third grade in case of childcare attendance, in comparison to non-attendance. This indicates that the language environment they experienced in parental or other forms of non-center care might have been more beneficial for their German reading comprehension than the multilingual environment in childcare, potentially due to a greater exposure to Luxembourgish/German within books and conversations in the family than in childcare.

RI 4 Home Environment Impact

With RI 4, the scope stretched beyond the confines of ECEC, looking more broadly at influences of children's language and literacy development in childhood, in particular, the role of exposure to language and media. While ECEC presents one context in which children encounter the language of instruction, children mostly experience language in other contexts, for example, within the family, among peers, or within different media. Study 4 underlines the importance of language exposure at home. Each additional context (i.e., family, peers, books, video, audio) that children came into contact with the languages of instruction, Luxembourgish or German, was associated with a 6 to 12 points higher Luxembourgish listening comprehension on the ÉpStan scale with a mean of 500 and an *SD* of 100. A similar, but slightly smaller association was observed for early literacy skills. Since home language groups vary strongly in their language exposure across contexts, the extent of exposure to the language of instruction appears to be a key factor contributing to the achievement gap between these groups. While exploratory, this finding is in line with the time-on-task concept (Esser, 2009; Gogolin & Neumann, 2009) as well as a previous study underlining the importance of language exposure for subsequent language outcomes in multilingual children (Thordardottir, 2019).

Additionally, children's use of and exposure to different media, such as television or audiobooks, has become more frequent over the last decades (Feierabend et al., 2024; Kieninger et al., 2023), taking its place next to the more traditional media of book reading and prompting a wave of research on its impact on children's development (Adelantado-Renau et al., 2019; Jing et al., 2023; Madigan et al., 2020). Study 4 corroborates previous research (e.g., Brown & Pivovarova, 2025; Niklas et al., 2016) by confirming the positive role of parent-child reading and storytelling activities for children's language and literacy development. Bookreading and storytelling activities present highly valuable opportunities for warm, attentive interactions between parent and child, talking about the plot, characters, and visual

elements. Often, parents use more sophisticated and complex language during shared book reading (Anderson et al., 2021; Ece Demir-Lira et al., 2019; Harris et al., 2011), which corresponds to the more formal, school-related language register required for literacy acquisition (Olson, 2016; Schleppegrell, 2001). Moreover, children get to experience written language and print culture, learning to decipher their first letters and gaining familiarity with the directionality in reading (Orellana et al., 2025). Coming into literacy has been described as gaining the analytic tools to become aware and conscious of language (Olson, 2016; Winchester, 2020). Thus, as new readers gain new vocabulary (Ece Demir-Lira et al., 2019) and an awareness of language, it is no wonder that frequent readers tend to read more proficiently and stronger readers read more frequently, creating an "upward spiral of causality" (Mol & Bus, 2011, p. 267; Van Bergen et al., 2018). Study 4 also indicated no or even negative associations of language and literacy with frequent contact to video. This finding may go back to stark differences based on content, language, quality of the consumed media (Kostyrka-Allchorne et al., 2017; Madigan et al., 2020), with the quality of video content varying more strongly than that of children's books. Exposure to audio media was neither beneficial nor detrimental for children's language and literacy development. Combining audio narration with written language and illustrations, as seen in digital storybooks, could potentially increase its benefits for children's language and literacy outcomes (see Egert et al., 2022; Wirth et al., 2020).

RI 4 + RI 5 Home Environment and Differences by Family Background

While a delayed development in the language of instruction may be typical among multilingual children, the resulting achievement gaps between home language groups, clearly observable in the Luxembourgish education system, are substantial and can have lasting implications for academic success. Thus, this thesis aimed to identify which aspects of language and media exposure were beneficial in the instructional language development for

three specific home language groups. In particular, monolingual children, successive bi- or multilingual, and simultaneous bi- or multilingual children were compared, adding a new component to HLLE research which had previously investigated the role of language and media exposure either in mono- or bilingual populations. Study 4 showed that while significant for all, children who spoke both Luxembourgish/German and another language with their parents showed the descriptively strongest association between exposure to Luxembourgish/German and language and literacy skills in those languages. Potentially, associations for those children might have been greater due to a greater variability in the exposure to Luxembourgish/German in this group, based on the language balance within families.

Notably, children who did not speak Luxembourgish/German at home showed significantly higher instructional language and literacy skills when frequently engaged in reading activities, even though the languages those occurred in were unspecified. Importantly, these associations were observed while controlling for exposure to Luxembourgish/German, suggesting that the benefits of reading and storytelling go beyond the specific language used. This finding aligns with Højen & Bleses (2023), who found that the home literacy environment was an important predictor of early literacy and language outcomes in second grade, independent of the type of bilingualism, children's language use, and parental proficiency in the language of instruction. These results underline the importance of engaging with written language, which fosters familiarity with and knowledge of letters as well as the development of metalinguistic competencies such as directionality of reading and plot structure (Orellana et al., 2025; Wesseling et al., 2017).

However, it cannot be ruled out that parental education might have influenced this relationship, as the SES variable that we controlled for only indicated parents' occupational status. Parental education, in particular, maternal education, has been repeatedly found to be closely connected to aspects of the HLE, such as reading frequency, and children's language

and literacy outcomes (Jeong et al., 2017; Mendive et al., 2017; Ribeiro et al., 2022; Sandsør et al., 2021), also in multilingual samples (Y. K. Kim et al., 2014). Thus, highly educated parents may have read to their child more often and further promoted their child's literacy acquisition through other beneficial learning activities and interactions.

All in all, RI 4 (in combination with RI 5) underlines the importance of the home environment and experiences with language, literacy, and other media in the development of a child, which may fit complementarily or discordantly with the environment a child experiences in ECEC. While the home context often offers more of a one-on-one interaction, ECEC environments typically provide greater educational stimuli through language and literacy resources, toys, and the early experience of community and group dynamics (Keller et al., 2013). Ultimately, both the home and the ECEC environment contribute to children's development. Thus, the discussion and evaluation of ECEC should always consider their interplay (Keller et al., 2013).

9.2 Implications of the Present Thesis for the Luxembourgish Context

The international research presented in this thesis demonstrates the considerable potential of ECEC to promote academic achievement and support the educational trajectories of diverse populations, provided that certain conditions are met by the ECEC system. While Luxembourg fulfills some of those conditions (high funding, universal access, high attendance), many of its characteristics resemble those of less effective ECEC systems (fragmentation, privatization, heterogeneity in regulations), which is mirrored in the results of this thesis.

In particular, effect sizes across all studies were small to very small (mostly under 0.1 *SD*). In experimental psychological research, effect sizes of around 0.2 *SD* are considered to be small effects. However, it has been argued that in educational research, and especially in policy evaluation, effect sizes of 0.2 or lower are common and may still be evaluated as

meaningful effects (Y. Anders et al., 2016; Elliot & Sammons, 2004), as observational research on ECEC is much less well-controlled than experimental research, and factors such as child, family, and ECEC characteristics play a large role in children's development. However, even compared to such a lowered benchmark, associations in the present thesis are small. Across the full population, one of the largest observed effect sizes—for the association of attending both childcare and preschool with language—was only .07 *SD*. This is nearly 10 times smaller than average effect sizes reported in a meta-analysis on public programs in the United States (DeAngelis et al., 2020). Notably, stronger effects of approximately 0.1 *SD* were found for certain outcomes[25] within a specific subgroup: those not speaking Luxembourgish/German at home.

Now, it remains a question for policy in Luxembourg whether the here uncovered relations of ECEC in Luxembourg are enough; whether it is acceptable that only one subgroup, those not speaking Luxembourgish/German at home, seems to benefit from ECEC attendance in academic achievement, leading to somewhat reduced achievement gaps. Stakeholders, such as parents, teachers, and politicians, need to think critically about what they expect from ECEC. If the goal is not merely to provide a convenient childcare solution during parental working hours, the ECEC system in Luxembourg must be reformed to bring out its full potential in positively shaping children's development, independent of their family background. To achieve this, the following four questions need to be addressed: 1) what role ECEC quality plays in the small effect sizes, 2) why Luxembourgish-speaking children do not seem to benefit from the language environments in ECEC, 3) why children with advantaged SES benefit over those with disadvantaged SES, and 4) how subsequent learning environments may be designed and aligned to sustain potential ECEC benefits.

[25] The specific associations were between childcare attendance and grade retention as well as voluntary preschool and Luxembourgish listening comprehension.

First, are the small effect sizes due to insufficient or inconsistent quality? To determine this, a systematic investigation—ideally, even long-term quality monitoring—across providers and sectors would be needed. In recent years, quality control visits have been expanded (Meisch & Hahn, 2025) but these primarily serve to guarantee basic standards of structural quality. The key dimension, process quality, remains unmonitored, despite recommendations from the OECD (2022b). A large-scale investigation into process quality could represent a crucial first step toward sustainably improving ECEC effectiveness by identifying precisely where and how improvements are needed, and by providing a foundation for evidence-based decision-making in ECEC policy and governance.

Second, what does the language environment in childcare and preschool look like for different student groups, and why do monolinguals not appear to benefit? To answer this, it is essential to understand what kind of language environment different groups need, as evidence suggests that different language learners may thrive under different conditions. For example, multilingual children may benefit more from shorter sentences in the language of instruction than monolingual children (Bowers & Vasilyeva, 2011). Currently, the language environments in Luxembourg's ECEC system—particularly in the context of the *éducation plurilingue* introduced in 2017—remain a black box for large-scale research. A systematic, in-field evaluation of the resulting language environments in childcare centers, e.g., including scales such as the Language Interaction Snapshot (Atkins-Burnett et al., 2011), would offer a valuable opportunity to shine a light on this issue.

Third, why do children from higher-SES families benefit more in some outcomes from ECEC attendance than children from lower-SES families? One explanation might be that there are SES differences in judgments of ECEC quality, as not every parent may have the time, resources, and awareness to research their choice in childcare extensively. As several studies have shown, parents tend to overestimate ECEC quality in a privatized market, due to the

limited and indirect information they have (Grammatikopoulos et al., 2014; Mocan, 2007). Detrimental consequences on a child's development are discovered late and are hard to reverse, which is why Spieß (2013) sees quality assurance as the responsibility of the state. Besides deciding which providers are allowed on the market, the state should also support all parents in evaluating the quality of ECEC providers in a privatized market, for example, by introducing a nationwide tiered quality label as it exists in the similarly heterogeneous ECEC system of Australia and is currently being developed for Switzerland (Edelmann et al., 2013; K. Spieß & Tietze, 2001; Tang et al., 2024). However, merely adding a label to childcare centers could inadvertently reinforce Matthew effects, as higher-quality childcare centers may become widely sought after and thus, less accessible to disadvantaged groups (Tang et al., 2024). Children from low-SES families might also benefit less because residential areas differ in the quality of childcare they offer (Mathers & Smees, 2014; Tang et al., 2024), a challenge unlikely to be resolved by simply adding a label. Thus, there would need to be an additional mechanism to protect children from low-SES families from attending the lowest quality settings. This could involve, for instance, ramping up overall quality control—potentially by leveraging CSA funding—and providing additional, flexible funding to improve childcare quality where needed, particularly for vulnerable populations (Lazzari & Vandenbroeck, 2012).

Lastly, how can subsequent learning environments (Bailey et al., 2017) be designed in a way that ensures the persistence of benefits beyond first grade? A starting point would be to improve alignment between different ECEC programs. While curricular alignment between preschool and primary school in Luxembourg is already relatively strong (Shuey et al., 2019), greater coherence and interconnectedness between non-formal (childcare) and formal (preschool) ECEC in terms of pedagogical concepts, resources, and structural frameworks has been strongly recommended by the *Observatoire national de l'enfance, de la jeunesse et de la qualité scolaire* (OEJQS) (2025). Beyond the alignment between non-formal and formal

ECEC, enriched and sustainable subsequent environments might also be fostered by actively involving parents in ECEC, thereby creating lasting impacts on the home environment. Research has shown that process quality in ECEC interacts with process quality at home (Pinto et al., 2013) and may even improve it (Kuger et al., 2019). Building on the importance of shared reading activities demonstrated in this thesis, the HLLE in a multilingual context such as Luxembourg should be investigated in more detail. Exploring potential interventions where ECEC staff collaborate with parents to cultivate a supportive literacy environment at home, e.g., via ECEC libraries, might help encourage frequent shared reading activities in the home language that parents feel most comfortable using.

9.3 Limitations and Outlook for Future Research

While specific strengths, limitations, and ideas for future research for each of the four studies are included in the papers, some general considerations are worth noting. In the following section, strengths, limitations, and potential avenues for future research related to various aspects of the present thesis are discussed.

Observational Design

All four included studies in this thesis utilize a correlational, observational design which limits the ability to draw strong conclusions about causal relationships between ECEC attendance and academic achievement. Consequently, this thesis deliberately avoids use of the term "effects", except in a statistical sense, and instead refers to "associations". To establish causal relationships, the gold standard is to use experiments, where participants are randomly assigned to different conditions, and external influences are carefully controlled or removed (Bortz, 2005). However, in ECEC research, experimental approaches are rarely used, as the randomized allocation of children to treatment (i.e., childcare attendance) and non-treatment groups is unfeasible from a practical and ethical standpoint (van Huizen & Plantenga, 2018).

Instead, this thesis relies on observational data of ECEC attendance and subsequent outcomes. As demonstrated in Study 1, attendance depends on family background, which is why all analyses on ECEC outcomes in this thesis controlled for family background influences. Nevertheless, it remains possible that some selection effects remained, for example, that unobserved characteristics in the child or the family impacted both the likelihood of ECEC attendance and later academic achievement, thereby confounding the observed association. For example, parents might base their decision to enroll their child in ECEC on the child's cognitive development or maturity at the time, which in itself might predict academic achievement in first grade, regardless of ECEC attendance. To address these limitations, future research should aim to collect more information on potential impact factors, such as children's developmental status prior to ECEC enrollment, and consider applying two statistical approaches that are described in the following section.

First, *propensity score methods* enable researchers to remove bias from non-randomized groups by matching or weighing the treatment and control groups conditional on covariates, creating more balanced groups and mitigating selection effects (Rosenbaum & Rubin, 1983). This method has been used in recent, methodologically rigorous research such as Soliday Hong et al. (2023), Ansari et al. (2021), and Cortázar et al. (2020). Incorporating this method into future research on the Luxembourgish ECEC system could strengthen the case for a causal relationship between ECEC attendance and academic achievement by helping to account for potential selection bias.

Second, interrupted time series, a special case of regression-discontinuity methods, is a commonly used approach in ECEC research and may demonstrate causal relationships under the condition that an external event introduces a natural cut-off point, such as ECEC reform (A. L. Gianicolo et al., 2020; Blanden et al., 2017). In the Luxembourgish case, the 2017 reform introducing twenty free childcare hours and the *éducation plurilingue* program would present

such an external event. Estimating causal relationships between the 2017 reform and academic achievement via interrupted time series presents an interesting avenue for future research (see Bousselin et al., n.d.).

Retrospective Parent-Report

The present thesis is based on retrospective parent-reported data of ECEC attendance. They have the advantage of being more easily connected to the individual child's characteristics and performance data, going beyond macro-level analyses on aggregated attendance and performance rates as often found in economics research (J. Anders et al., 2019; Raudenbush & Eschmann, 2015). However, retrospective parent-reported data also have their drawbacks.

Reporting on a child's ECEC attendance five to six years after initial entry may be affected by memory biases or inaccuracies, particularly in cases involving complex attendance patterns, such as parallel enrollment in multiple ECEC types or frequent transitions between providers (Bollig et al., 2016). Additionally, social desirability bias may play a role with parents, indicating either a bias towards higher or lower dosage of ECEC provision, based on the value or stigma they associate with (early) non-parental childcare (see these Luxembourgish newspaper articles as examples of the heated societal debate; Gantenbein, 2023a, 2023b).

Together, these factors can introduce inconsistencies and reduce the reliability of the data. Therefore, supplementing future research on Luxembourg's ECEC system with administrative attendance data would add another layer of validation to current findings. For this, however, a national database has yet to be created (OEJQS, 2025).

Broad Large-Scale Quantitative Findings on the "Black Box" of ECEC

Due to the large-scale quantitative approach of this thesis, it was possible to gain insight into the overall association of ECEC attendance in Luxembourg with academic achievement based on full-population data. This meant that it was not necessary to extrapolate trends from small, potentially unrepresentative groups or individual, particularly engaged institutions to the entire population. This work therefore helps to identify broad national trends in relation to ECEC. At the same time, this method has the disadvantage that the exact mechanisms that link academic achievement to the highly variable and heterogeneous ECEC program in Luxembourg remain unclear. For example, the concrete practices in the field as well as the effects of specific educational measures, provider characteristics, and educator attitudes on child development, remain hidden. ECEC in Luxembourg thus remains something of a black box in this thesis.

To discover the specific “recipe” for a sustainably valuable and supportive experience in ECEC, which may be of value to both policymakers and ECEC staff, the following two aspects should be taken into account in future research projects: First, studies should include *diverse perspectives and voices from the field* to assess which resources may be needed in ECEC to facilitate the work of professionals and which support they may require from academia. Such a multi-perspective approach might value and appreciate the work of professionals in the field, increase acceptance of an external evaluation, and empathize that there is a shared goal that researchers and staff are working towards. Secondly, a *multi-method approach* should be used, incorporating questionnaires, standardized tests, and external, standardized observations of process quality to maximize objectivity and interrater reliability.

Potential models for such assessments can be found in Anders et al. (2016) who, i.a., uses the ITERS-R scale (Harms et al., 2014; Tietze et al., 2007), and the pre-COOL study on ECEC quality in the Netherlands (Leseman et al., 2017; van der Werf et al., 2020). For

example, Pre-COOL utilized both surveys for managers and employees, as well as professional observations of process quality in a subset of facilities. From center managers, researchers sought to learn about characteristics of the facility, the educational vision, and structural quality indicators, such as regulations on continuous professional development. ECEC staff were surveyed on topics such as work climate and job satisfaction. These are critical aspects for ECEC effectiveness as high staff turnover, often driven by poor working conditions and dissatisfaction, can negatively affect children's developmental outcomes (Center on the Developing Child at Harvard University, 2007; McDonald et al., 2018). To observe process quality in selected ECEC centers, the study used the Classroom Assessment Scoring System Toddler (CLASS Toddler; Paro et al., 2012). The instrument assesses *emotional quality* in the sub-facets of positive climate, negative climate, teacher sensitivity, regard for child perspectives, and behavior guidance, and *educational quality* in the sub-facets of facilitation of learning and development, quality of feedback, and language modeling.

By employing such a comprehensive multi-method, multi-perspective approach in future research, more nuanced insights into the mechanism underlying ECEC benefits as well as knowledge on the necessary conditions for fostering children's development in ECEC may be generated specifically for the Luxembourgish context.

Narrow Focus on Academic Achievement

The present thesis has focused on academic achievement due to its key role in facilitating further learning, professional trajectories, and individual and societal prosperity (Chiswick et al., 2003; Ritchie & Bates, 2013). However, ECEC attendance also impacts other important aspects of a child's development, such as social and emotional competencies (Bennett, 2012; Camilli et al., 2010). Especially early and extensive ECEC attendance has been linked to increased behavioral problems or increased stress levels in children (Belsky et al.,

2007; Bradley & Vandell, 2007; Coley et al., 2013; Loeb et al., 2007; Roisman et al., 2009). However, high-quality care and nurturing, reliable relationships with caregivers in ECEC might alleviate these detrimental effects, even leading to benefits for children's social and emotional development (Kluczniok et al., 2025; Vandell et al., 2010; Von Suchodoletz et al., 2023). While this topic has not been the focus of the present thesis, it would be an important aspect to consider in future research on Luxembourg's ECEC system.

Taken together, to conduct a comprehensive, gold-standard evaluation of ECEC effectiveness in Luxembourg, researchers will need to find a way to deal with the complex and at times messy realities of the "living lab" of Luxembourg. The present thesis employed a wide variety of statistical methods, cohorts, and academic outcomes, in an effort to find tailored approaches that address the complexity of the research questions and the ECEC landscape. However, a more standardized approach, more detailed data, or smaller research questions as described in the previous paragraphs would be needed to get closer to a reliable estimation of a causal effect of ECEC. As "you cannot fix by analysis what you bungled by design"(Light et al., 1990, p. v), this was beyond the scope of the present thesis situated in the heterogenous ECEC system of Luxembourg.

10 Conclusion

In the face of considerable educational inequalities in the multilingual Luxembourgish context, the present thesis explored ECEC as a promising strategy to counter such disparities, in particular those based on differences in language use at home.

Analyses of high-quality, large-scale data from the Luxembourg School Monitoring Programme (Martin et al., 2015) including retrospective reports of ECEC attendance provided indication of mostly positive relationships between attendance of different types of ECEC and several achievement domains, with stronger benefits for formal ECEC types and

Luxembourgish listening comprehension as an outcome domain. The thesis, however, also revealed that, within Luxembourg's heterogeneous and partly privatized ECEC landscape, large-scale, population-wide benefits for academic achievement were notably smaller than those found in other research. Moreover, persistence of ECEC-related benefits beyond the first grade was visible only in some, not all, outcomes and timepoints. These findings underscore the extent to which ECEC outcomes rely on system-level characteristics, and by extension, the quality of provision—an aspect which has yet to be systematically investigated on a process level in Luxembourg.

The thesis also investigated the common assumption that disadvantaged groups of students benefit more from attending ECEC. While rare Matthew effects are indicated by high-SES students benefiting more in some outcomes, ECEC in Luxembourg seems to particularly support the academic achievement of children in families in which the instruction languages Luxembourgish and German are not spoken. Especially promising was the finding that disparities in the grade retention rates between home language groups around age 11 were mostly alleviated with childcare attendance. More research is needed to thoroughly examine the mechanisms behind both of these moderations, especially potential disparities in access to high-quality care which may drive the Matthew effect. With the available data, the present thesis has contributed to the understanding of attendance patterns in ECEC in Luxembourg by confirming consistently high attendance across various types, while also revealing subtle disparities in attendance between migration and language backgrounds.

The thesis was also able to replicate previous findings on nonlinear relationships between ECEC dosage and achievement (Del Boca et al., 2022; Loeb et al., 2007), with the highest academic outcomes found for a childcare duration between one and three years, depending on the family background. The thesis indicated that remaining the full four years in childcare was instead linked to lower or not distinctly higher outcomes, especially for

advantaged home language groups, which may illustrate the importance of a timely transition into preschool.

Future research may also use the present findings on the positive role of shared parent-child literacy activities as a jumping point to further investigate the role of home learning environment for diverse multilingual groups, including the interplay between ECEC and the home environment, which might present a starting point for potential interventions to promote home reading activities.

All in all, the present thesis aims to underline the importance of early investments into children's school success, while illustrating that so far, the full potential of ECEC in Luxembourg has not been realized yet. To generate a deeper understanding of how the system must be formed to truly benefit children, parents, and society in multilingual Luxembourg, the quality of ECEC must become the focal point of future research and policy.

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