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Loss of Vocabulary Growth during Lockdown? Stability in Language Trajectories among bi- and monolingual Children during the School Closures 2020/2021

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ABSTRACT

Theories of language acquisition suggest that primary school constitutes a pivotal source of majority-language exposure, which is particularly important for bilingual children. During the periods of school closures caused by the COVID-19 pandemic, this source of language input was reduced or even entirely unavailable for several months, raising the question of how the language competences of mono- and bilingual children developed during this time. This study examines the German receptive vocabulary development of mono- and bilingual primary school children in Germany at the time of the COVID-19 school closures, using data from the Newborn Cohort of the German National Educational Panel Study from 2015 to 2021. Contrary to the theoretical expectation of exacerbated educational disparities, our findings reveal no significant widening of the existing vocabulary gap between mono- and bilingual children during the pandemic. Despite the potential for reduced German language exposure, particularly among bilingual children, vocabulary trajectories remained surprisingly stable in both groups, with bilingual children even showing signs of a slight but significant catch-up effect. Additional analyses to examine potential growing vocabulary gaps by migration background or parental education yielded no evidence of a widening achievement gap in vocabulary. These findings may be attributed to the well-documented stability of receptive vocabulary, as well as to various other factors outlined in the discussion. Our study contributes to the body of differentiated research on educational impacts of the pandemic and highlights the importance of careful examination regarding the relationship between school and competence development in the context of social inequalities.

1. Introduction

Children's everyday lives and learning were severely affected by the COVID-19-related school closures, which lasted several months in 2020 and 2021. Almost all countries imposed school lockdowns at the height of the pandemic, with Germany being one of the EU countries with relatively long phases of school closures (Freundl et al., 2021). Given the wide range of social and cultural backgrounds and corresponding learning environments of students, it is reasonable to assume that school closures led to increasing inequalities in specific learning domains and to a potential global learning loss among children (Stanat et al., 2022). The early educational stages within the school system are crucial as they set the course for children's long-term educational paths, especially in a highly stratified educational system like Germany's (Henninges et al., 2019). One critical preliminary competence domain in early educational stages is proficiency in the language of instruction, impacting not only other essential competence domains like reading (Huang et al., 2021; Sénéchal et al., 1998; Sénéchal & LeFevre, 2002) but also long-term educational achievements (Chilla, 2017; Lenhard et al., 2015; Novita et al., 2022). Hence, it is important to examine competencies in vocabulary skills to identify reasons for a learning loss in subsequent competencies .

Today's primary school children in Germany come from diverse language backgrounds with 42 % of children having a migrant background (Destatis, 2024) and 20 % of private households in which German is not the sole language spoken at home (Destatis, 2023). As

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language use is one important mechanism for intergenerational integrational processes of migrants (Esser, 2006), the focus of this study lies on the family's language. While many studies focus solely on families with a migration background, from our point of view it is more fruitful to take the home language as a potential mechanism into account, as it is theoretically more precise for explaining the relationship between school closures, language exposure and vocabulary growth. During school closures, children from bilingual families, defined as families in which a language other than the language of instruction (German) is spoken at home, received proportionally less daily German language input than before. In contrast, monolingual children, who only speak German at home, benefited from consistent language input. From a theoretical perspective, access to and exchange with teachers instructing German at native speaker level outside of the private sphere is thus particularly important for bilingual children. Since proficiency in the language of instruction is a crucial prerequisite for further skill acquisition such as reading and writing (Thorndike, 1973; Verhoeven et al., 2011), understanding whether and how children's vocabulary skills were affected by school closures is vital. At the same time, research on summer learning gaps in the US suggests that vocabulary skills are comparatively robust to disruptions in exposure, unlike academic skills such as reading. This leaves open the question of whether vocabulary growth was as severely affected by school closures as other school-related competencies (Cooper et al., 1996). The aim of this study is therefore to retrace the vocabulary development of bilingual and monolingual children during the times of COVID-19-related school closures by asking the following questions: What consequences did the loss of access to German language input during school closures have for the development of German vocabulary skills of monolingual and bilingual children? To what extent did German vocabulary development differ between the two groups during the period of school closures? Furthermore, since pandemic-related learning deficits seem to be socially stratified (Betthäuser et al., 2023), we examine the vocabulary growth by migration background and parental education as dimensions of social inequality.

We investigate these questions by using longitudinal large-scale panel data of Starting Cohort 1 of the German National Educational Panel Study (NEPS) and contribute to the existing literature on learning loss and learning differences in the aftermath of the COVID-19 school closures in several ways. To the best of our knowledge there is no representative study specifically examining the language development of students with diverse language usage during the times of the COVID-19 pandemic. Only a few studies investigate differential effects of school closures in Germany for students with and without a migrant background or for students with different socioeconomic factors (Förster et al., 2023; Ludewig, Schlitter, et al., 2022; Schult et al., 2022; Weber et al., 2021). As mentioned earlier, it is known that inequalities in early competencies are relevant for later educational outcomes as a path dependency. Therefore, it is crucial to explore the potential impact the loss of language exposure has on mono- and bilingual primary students' vocabulary skills. Additionally, this paper offers a relevant contribution to explaining possible differences in the development of a pivotal competency domain during the early phase in the education system.

2. School Closures & Learning

Research conducted before COVID-19 school-lockdown has shown that primary school children from families, where the language of the host country is not spoken exclusively, show lower vocabulary skills compared to their peers (e.g., Barthel, 2019; Novita et al., 2022; Sprong & Skopek, 2023). Negative influences on children's vocabulary skills are well known if their family's language use differs from the language of the host country (Becker, 2011; Edele et al., 2023; Sprong & Skopek, 2022).

Studies focusing on the impact of the COVID-19 school lockdowns on competencies of children have been summarized in systematic reviews by Betthäuser et al. (2023), Hammerstein et al. (2021), Donnelly and Patrinos (2022) and König and Frey (2022). The majority of COVID-19-related studies find evidence for the expected learning loss of primary school students after COVID-19 school-lockdown (Betthäuser et al., 2023; Donnelly & Patrinos, 2022; Engzell et al., 2021; Kuhfeld & Lewis, 2022; Ludewig, Kleinkorres, et al., 2022; Maldonado & De Witte, 2022; Weber et al., 2021), although not all studies report such findings (see Betthäuser et al., 2023 for a systematic overview of effect sizes). In general, primary school students' achievements seem to be more negatively affected by the school lockdown compared to secondary school students (Hammerstein et al., 2021; Tomasik et al., 2021) making a focused investigation on younger students particularly pertinent. However, there are some mixed findings as well (Depping et al., 2021; Förster et al., 2023). Varied COVID-19 policies and the resulting differences in lockdown durations and home-schooling arrangements across countries complicate international comparisons, further challenging the validity of universal conclusions.

In the following, we summarize studies that investigate differences in language related competencies of primary school students and examine effects of COVID-19 related school-lockdown. Furthermore, we focus on the few studies that consider not only social origin but also ethnic family background characteristics as factors influencing differences in competencies during or after the school-lockdown.

Engzell et al. (2021) compare differences in competencies of a pre-lockdown cohort of Dutch primary school students with differences in competencies of a post-lockdown cohort. They use test scores in various domains and reveal that a learning loss of one-fifth of a school year has occurred and that losses are bigger for students from less-educated homes. Maldonado and De Witte (2022) complement the study by including home language and school level as aggregated factors influencing differences in competencies before and during the school-lockdown. Their results reveal that children show significantly lower test scores for reading, writing and language skills in Dutch after the COVID-19 school-lockdown compared to previous cohorts. Yet, they do not find significant differences in learning losses based on the aggregated group level by including the share of students with another home language or from disadvantaged neighborhoods. The findings of Kuhfeld and Lewis (2022) for first and second grade students in the US contradict these results, as they find larger differences in reading achievements for ethnic minority students (except for Asian Americans) compared to white students between pre- and post-COVID-19 cohorts. In addition, students in high-poverty schools appear to be more impacted by the school-lockdown. Sun et al. (2023) provide first insights into a varying competence development by domain between mono- and bilingual primary school children in a small, socially selective US-sample. Contrary to expectations, bilingual children revealed a significantly larger vocabulary growth than their monolingual peers at the times of school disruptions, effectively reducing the vocabulary gap between these groups and providing initial evidence of the robustness of vocabulary to disruptions in exposure in the context of school closures. In contrast, the reading gap between monolingual and bilingual children widened over the same period, mirroring findings from summer learning gap research in the US (Cooper et al., 1996).

To the best of our knowledge, no representative study specifically explored the development of German vocabulary skills among primary school students during the COVID-19 school lockdown. On a regional level of the federal state of Brandenburg, Hoffmann et al. (2024) investigated inequalities in the language development of 5–7 year old children by different language use and by differences regarding socio-economic status. While the language development of children with a non-German mother tongue remained stable during the observed period (2018–2021), the authors observed language delays in children from families with a low social status.

Depping et al. (2021) do not find evidence for an increasing learning loss in reading or math competencies for more than 12,000 students in grade four and five in the city of Hamburg (Germany). They conclude

that the school closure was well compensated for. Ludewig, Schlitter et al. (2022) investigate reading competencies of fourth grade students in Germany before and after the school-lockdown and include ethnic factors. While they find a substantial overall decline in the mean reading achievement corresponding to one-third of a school year, they do not find significant changes of achievement gaps between students with different ethnic backgrounds. Including the proportion of students with a migration background, Schult et al. (2022) compared reading and math competencies of students in South-West-Germany (Baden-Württemberg) at the end of primary school after the school-lockdown with the competence scores of same age students in the three years before the school-lockdown. Confirming the results of Ludewig, Kleinkorres, et al. (2022), they find slightly lower competence scores after two months of school closure with the proportion of students with migration background playing only a minor role in mediating this learning loss. The results of an online-survey by Steinmayr et al. (2021) further confirms, for the German context, that migration background does not correlate with the students' language competencies during school lockdown. However, it should be noted that their results relate to parental rating and not to competence measure tests assessed by the students.

Overall, the current state of research for the German case only partially points to a loss of learning and increasing differences in competence between children with different language use during the COVID-19-pandemic. The findings could also point to a continuing pattern of social and ethnic educational inequalities in Germany that pre-existed the COVID-19 lockdown. Although numerous studies have scrutinized the lockdown's effects on reading and mathematical competencies, next to none has specifically focused on the differential development of German vocabulary skills and comparing monolingual and bilingual children. In contrast to some of the presented cross-sectional research, this study utilizes longitudinal vocabulary assessments before and after the pandemic to carefully assess the impact of school closures on language development. So far, it is not clear what role the COVID-19 school-lockdown has had for the development of differences in vocabulary skills between children with different language backgrounds. Consequently, this study contributes to the literature by examining the impact of the COVID-19 school lockdown on the vocabulary development of monolingual and bilingual primary school students in Germany, thereby offering new insights into the ramifications of educational disruptions caused by the pandemic.

3. Theoretical Framework

We adopt the theoretical model of language learning according to Esser (2006), to explain skill acquisition and differences in skill acquisition between students with different German language use at home during and after the COVID-19 school-lockdown. Derived from the foundational theoretical work of Chiswick and Miller (1998, 2001), Esser applies his model to the importance of language acquisition for migrants' school performance. Hence it seamlessly aligns with our research questions.

The model outlines essential key parameters for children's language acquisition, offering a comprehensive framework to analyze language learning dynamics. First, the perceived benefits of the competence acquisition *U(qu)* in contrast to the perceived benefits of a status quo *U (sq)*, in which no further competence acquisition happens, highlight the motivation to learn. Second, the model considers the costs associated with competence acquisition, *C(qu)*, encompassing not just direct financial expenses but also transaction costs, such as the additional effort required for learning under resource constraints (Esser, 2006: 297). Third, the access to an environment *P(exp)*, where competence acquisition can actually take place, is necessary and fourth, the amount of efficiency *P(eff)* (amount of skill improvement per time unit) for competence acquisition in a certain situation determines the rate of skill acquisition with higher efficiency signifying a more beneficial setting for rapid competence development (Chiswick & Miller, 2001). Taken together, access and efficiency are the opportunities of competence acquisition. Combining costs and opportunities of learning, one can speak of barriers to learning, which may make further acquisition difficult. If – on the other hand – learning costs are low and opportunities are high, barriers are small and further acquisition becomes more likely. The interaction of the parameters for competence acquisition represents the following equation (Esser, 2006: 293):

Formula: $U\,(qu) - U\,(sq) > C\,(qu) / P\,(exp) * P\,(eff)$

Following the logic of the model, an investment in further German vocabulary acquisition takes place if the perceived benefit for it is greater than the perceived benefit for maintaining within the status quo (on the left side of the equation). Accordingly, further vocabulary acquisition occurs when the benefit to do so is greater than the benefit to maintain the status quo. It is assumed that bilingual as well as monolingual German-speaking families estimate a high benefit of German vocabulary acquisition of their children visiting German primary schools. Therefore, there should be no systematic differences on the left side of the equation between the groups.

However, differences in the amount of learning barriers (on the right side of the equation) are assumed to be the main reason for distinctions in German vocabulary acquisition between mono- and bilingual children. School is a learning environment, which provides critical access (*P (exp)*) to German vocabulary through regular, professionally guided exposure to advanced levels of the language. This access to a learning environment is directly linked to a certain level of efficiency (*P (eff)*) through consistent and frequent exposure to a high-quality language environment. As schools usually offer such access both in quantitative (several hours of school per day) as well as in qualitative terms (introduction and input in German language by professional teachers), schools efficiently enhance German vocabulary skills of all children.

To sum up, children's ability to expand their German vocabulary competencies is dependent upon their access to resources that support an efficient learning environment. As the COVID-19 school-lockdown reduced the access to professional and high-level language input through school for all students, a learning loss for all students is expected (Hammerstein et al., 2021; Maldonado & De Witte, 2022). We therefore state the following hypothesis about cross-group trajectories in German vocabulary due to the school-lockdown:

Hypothesis 1. German vocabulary acquisition of bilingual and monolingual German speaking children slows down following the COVID-19 school-lockdown.

For children from bilingual families, not speaking solely German in non-school settings, school is a particularly crucial learning environment and provides important access to German language on a regular basis. For many bilingual children, school represents a primary environment for engaging with the German language on a daily basis. Accordingly, some studies suggest that during elementary school language related inequalities remain stable or even decrease (Downey et al., 2004; Sprong & Skopek, 2023). However, during the COVID-19 school-lockdown, access to this efficient learning environment for further German language improvement was significantly lower for them compared to children from monolingual German speaking families. Given that children from bilingual families engage in environments where German is not the sole language spoken, they naturally have less daily exposure to German language compared to their peers from monolingual German-speaking families. This reduced exposure implies fewer opportunities for learning and practicing German. Under these circumstances, it is expected that bilingual children show lower German vocabulary growth. Therefore, we state the following hypothesis about group differences in German vocabulary acquisition due to the COVID-19 school-lockdown:

Hypothesis 2. Disparities in German vocabulary acquisition between bilingual and monolingual German speaking children widen because of

the COVID-19 school-lockdown.

Although the theory of language acquisition points to a decline in vocabulary growth as a consequence of school closures, empirical research suggests that receptive vocabulary, the outcome of interest in this study, is remarkably robust to disruptions in exposure. Research on language attrition indicates that receptive language skills, such as word comprehension and reading, are more robust to attrition than productive language skills like speaking and writing (Jessner et al., 2021). Vocabulary appears to be even more robust to attrition than reading comprehension. Cooper et al. (1996) demonstrated in a meta-analytic review of competence development during the two-month summer break in the US that while children's productive vocabulary continued to grow, their reading skills declined. Moreover, the study by Sun et al. (2023) on vocabulary and reading development during school closures in the US shows that children's vocabulary gains were age-appropriate and that the achievement gap between mono- and bilingual primary school students even narrowed during the COVID-19 period in favor of bilingual students, while their gains in reading comprehension declined. Given the documented robustness of receptive vocabulary to temporary exposure reduction, we propose a third and alternative research hypothesis based on empirical evidence, countering the previous two hypotheses derived from theory:

Hypothesis 3. The receptive vocabulary growth of monolingual and bilingual German-speaking children remains stable during the school closures of 2020/2021.

4. Data & Methods

4.1. Data

Our analyses are based on the Newborn Cohort Study (Attig et al., 2023) of the German National Educational Panel (Blossfeld & Roßbach, 2019; NEPS Network, 2023), which started in 2012 with 3481 representatively drawn infants at the age of around seven months and their parents. Since then, assessment took place once every year by testing the child in several cognitive domains and interviewing one parent about various topics of family life, home learning environment, socioeconomic status and education.

For our research endeavor we use all waves, in which the receptive vocabulary was administered. These are the waves four, six, eight, and ten of the NEPS Newborn Cohort, corresponding to children's age of approximately three, five, seven, and nine years. Wave ten was measured in 2021 starting from calendar week 21 (end of May), almost at the same time of the nationwide re-opening of most primary schools in Germany one week later (Ludewig, Schlitter, et al., 2022). The other waves took place before lockdown in 2019, 2017 and 2015 respectively. Since our main interest lies in the vocabulary after the school closures, our sample is restricted to only those children with a valid vocabulary test in 2021. It is noteworthy that from the time of assessment in spring 2019 to the first school closure in Germany in March 2020, there was one year of regular in-person schooling and therefore no measurable disruption in language exposure. This year of regular schooling could lead to measurement error when assessing vocabulary growth from pre-pandemic 2019 to post-school-closure 2021. For instance, above-average vocabulary growth from 2019 to 2020 could have served as a potential buffer against the loss of growth during the period of home-schooling from March 2020 to May 2021. For this reason, we compare vocabulary growth to the age-appropriate values of the norming sample, derived from a large nationally representative dataset (Lenhard et al., 2015), in order to contextualize overall growth from 2019 to 2021. Additionally, like most other panel studies, the NEPS also deals with selective panel attrition (Würbach et al., 2016). To diminish the bias of this social selection, we calculated sample weights for wave 10 (see Table A1 in the appendix for an overview of selective panel attrition).

4.2. Dependent Variable: Receptive Vocabulary

The vocabulary test used in the NEPS Newborn Cohort is the translated and edited fourth version of the Peabody Picture Vocabulary Test (PPVT-4; Lenhard et al., 2015), which is an internationally approved assessment for the child's receptive vocabulary (Dunn & Dunn, 2007). In the digital form of this test, the child sees four hand-drawn pictures while an audio voice names a word and asks the child to point to a specific picture. The entries are scored until the child makes too many mistakes. The PPVT is age sensitive, meaning that the test can be used to measure and compare vocabulary skills of children between three and 16 years.

4.3. Independent Variables

4.3.1. Family Language

Our key variable for grouping is the family language at home, which is further distinguished into five categories ranging from "only German" to "only other Language". We generally defined bilinguals as children who speak another language at home instead of German, or in addition to German. Children, who speak only German at home, are correspondingly defined as monolinguals. To provide further robustness, we constructed an additional definition for bilinguals, who are speaking German at most 50 % of the time in their families. In this case, monolinguals are children who speak either only or mostly German at home.

4.3.2. Migration Background

To define migration background, we used birth countries of parents and grandparents (all children in the NEPS Newborn Cohort were born in Germany). We differentiate between the second generation, interethnic and the third generation. A child is considered to be in the second migration generation, if both parents were not born in Germany. If one parent is born abroad and one parent and the corresponding grandparents were born in Germany, a child is considered as interethnic. If at least one grandparent is born abroad, the child is grouped into the third generation of migration. This approach provides more distinct insight into different aspects of migration background (Olczyk et al., 2016).

4.3.3. Highest Parental Education

To examine potential growth differences by socio-economic status, we use the highest familial education. Because of low case numbers, we merged families with a lower or intermediate secondary educational certificate as well as those without any school leaving certificate into one group. The other two groups consist of families with an upper secondary qualification and families with a tertiary degree as highest level of education.

4.4. Control Variables

We use the highest ISEI-08 in the family as an additional instrument to control for socio-economic differences (Ganzeboom et al., 1992; Ganzeboom & Treiman, 1996). We further add binary variables to control for influences that are associated with the school closures. This includes the possibility of working from home for the interviewed parent, since the amount of parental exposure might be higher for children, whose parents can work from home. We further control for the admission to emergency childcare, which grants children an alternative source of structured German language exposure outside the home setting during school closures. In Germany, emergency day care was introduced for parents with jobs of "system relevancy", who cannot work from home and therefore require childcare. To capture potential compensatory effects of home schooling, we included several controls for the home environment: the number of siblings and the number of books in the household as structural characteristics as well as the child's time spent reading and the frequency of joint reading activity with the parent to account the processes in the home environment. Furthermore,

we control for the child's general usage of digital media and if the frequency of online learning videos rose during the times of school closures. Since population density is a driving factor for the prevalence of infections and is thus affecting the re-openings of schools (Haderlein et al., 2021), we included the number of inhabitants in the residential area. Lastly, we added the child's sex assigned at birth.

4.5. Methodological Approach

Our analysis framework consists of linear mixed-effects models, in which the repeated measurements are clustered within children, to utilize the panel structure of the NEPS. In the models, we employ interactions between years of vocabulary test assessment and the corresponding group of analysis (e.g., mono- and bilinguals). The interaction term represents the growth of vocabulary between the last and the current assessment in comparison to the last and current assessment of the reference group. Positive values indicate a larger growth in the respective time period compared to the reference group, while negative values indicate a smaller growth. This approach allows us not only to model the vocabulary growth from before (2019) and after (2021) the school closures over groups but also gives us additional information about prior growth rates to put the results into a more comprehensive perspective. However, the results of this analysis are descriptive in nature. Our primary goal is to trace and compare the growth rates of mono- and bilingual children and to benchmark them against the norming sample, which enables us to check for unusual vocabulary growth during the period of school closures.

5. Results

Table 1 presents the descriptive sample statistics. Our primary group of interest are bilinguals, who are defined as children from families, in which any other language in addition to German is spoken (N = 241). This equals 19 % of our sample, while monolingual children, who only speak German at home, represent the vast majority of our sample with 81 %. Within the group of bilinguals, it is noteworthy that only 24 % of the children speak another language as frequently as, or more frequently than German at home. Therefore, we conducted an additional analysis of those bilinguals, who speak another language than German at least 50 % of the time at home (N = 59) as a sensitivity check. Fig. 1 illustrates the development between the groups of mono- and the entire group of bilinguals over time and age. We further included (as a reference group) the average values for each age of a representative norming reference sample for the German version of the PPVT (Lenhard et al., 2015)[1].

Contrary to our initial expectations outlined in research hypothesis one, the descriptive statistics of Table 1 and the trajectories with comparison to the norming sample do not indicate a pronounced decline in vocabulary growth post-school closures across the sample. Instead, the average vocabulary trajectories of mono- and bilingual children appear to follow a pattern similar to the norming sample, with consistent differences in overall levels. This observation suggests that the impact of the lockdown on the immediate vocabulary development of both bilingual and monolingual children may not be as substantial as anticipated by theory. However, the consistent gap between mono- and bilinguals starts as a five-point difference in vocabulary scores at age three, which subsequently widens to twelve points by age five and a small decline thereafter, with a nine-point-difference at age seven and an eight-point-difference at age nine. This pattern underscores a consistent disparity in vocabulary acquisition favoring monolingual German-speaking children over time.

Our empirical analyses (see Fig. 2 and Table A3 & A4 in the appendix) validate this impression: The interaction between age and group

Table 1
Weighted descriptive statistics by group.

	Monolinguals	Bilinguals	Total
Number of Cases	1009 (81 %)	241 (19 %)	1250 (100 %)
Family Language	***		
Only German	1009 (100 %)	0 (0 %)	1009 (81 %)
Mostly German, sometimes other Language	0 (0 %)	182 (76 %)	182 (15 %)
Equally often German and other Language	0 (0 %)	17 (7 %)	17 (1 %)
Mostly other language, sometimes German	0 (0 %)	39 (16 %)	39 (3 %)
Only other Language	0 (0 %)	3 (1 %)	3 (0 %)
Vocabulary Age 3 Ø [0−228]	57 (21)***	52 (22)	56 (22)
Vocabulary Age 5 Ø [0−228]	110 (20)***	98 (22)	108 (21)
Vocabulary Age 7 Ø [0−228]	146 (19)***	137 (23)	144 (20)
Vocabulary Age 9 Ø [0−228]	173 (16)***	165 (21)	172 (17)
Generation Status	***		
No Migration Background	834 (83 %)	49 (20 %)	882 (71 %)
2nd Generation	17 (2 %)	111 (46 %)	129 (10 %)
Interethnics	48 (5 %)	45 (19 %)	93 (7 %)
3rd Generation	110 (11 %)	36 (15 %)	145 (12 %)
Highest ISEI in Family	67 (16)***	61 (20)	66 (17)
Highest Parental Education	***		
Intermediate Secondary or Lower	222 (22 %)	52 (22 %)	274 (22 %)
Upper Secondary	214 (21 %)	90 (37 %)	304 (24 %)
Tertiary Degree	573 (57 %)	99 (41 %)	672 (54 %)
Home Office during Pandemic	**		
Never	375 (37 %)	104 (43 %)	479 (38 %)
At least once in month	634 (63 %)	137 (57 %)	771 (62 %)
Emergency Childcare	228 (23 %)	43 (18 %)	271 (22 %)
Child's Gender: Female	476 (47 %)	137 (57 %)	614 (49 %)
Number of Siblings in HH	1.10 (0.74)	1.20 (0.90)	1.12 (0.78)
Number of Inhabitants in Residential Area	*		
Below 100 000	244 (24 %)	28 (11 %)	272 (22 %)
100 000–500 000	362 (36 %)	92 (38 %)	454 (36 %)
500 000 or more	403 (40 %)	121 (50 %)	525 (42 %)
Increased use of Learning Videos in 2021	754 (75 %)*	142 (59 %)	896 (72 %)
Frequency of Joint Reading with Parent			
Once a week or less	278 (28 %)	67 (28 %)	345 (28 %)
Multiple times a week	355 (35 %)	92 (38 %)	447 (36 %)
Once daily	331 (33 %)	71 (29 %)	402 (32 %)
Multiple times daily	45 (4 %)	11 (4 %)	56 (4 %)
Frequency of Reading Alone			
Once a week or less	117 (12 %)	37 (15 %)	154 (12 %)
Multiple times a week	239 (24 %)	57 (24 %)	296 (24 %)
Once daily	330 (33 %)	69 (28 %)	399 (32 %)
Multiple times daily	323 (32 %)	79 (33 %)	402 (32 %)
Number of Books in HH	***		
0–25	31 (3 %)	19 (8 %)	50 (4 %)
26–100	204 (20 %)	52 (22 %)	257 (21 %)
101–200	206 (20 %)	55 (23 %)	261 (21 %)
201–500	391 (39 %)	74 (31 %)	465 (37 %)
> 500	177 (18 %)	41 (17 %)	218 (17 %)
Child's Frequency of Digital Media Usage			
Less than once a week	102 (10 %)	16 (7 %)	118 (9 %)
Once a week	135 (13 %)	31 (13 %)	166 (13 %)
Several times a week	412 (41 %)	116 (48 %)	528 (42 %)
Daily	360 (36 %)	78 (32 %)	438 (35 %)

Notes: Means and shares of variables. *$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$ for significant differences between Monolinguals and Bilinguals. To determine significant mean differences (linear for metric variables, logistic for binary variables and ordinal logistic for categorical) weighted bivariate regressions were

[1] Due to restricted data access, it is not possible to examine the norming sample by home language.

used. Source: National Educational Panel Study (NEPS) Newborn Cohort, own calculations.

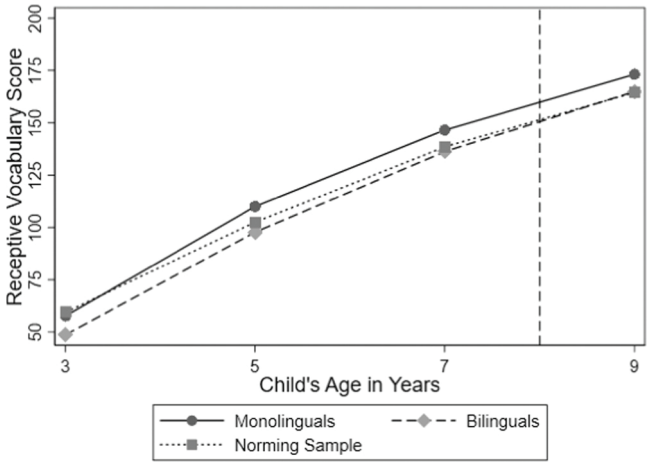

Fig. 1. Weighted average receptive vocabulary score by group and age. Children from "only German" speaking families are considered Monolingual. Children from families in which another language is spoken (in addition to German) are considered Bilingual. Norming sample represents the appropriate age average provided by Lenhard et al. (2015). Notes: Vertical line marks the approx. beginning of school closures. Years of assessment: Age 3 = 2015, Age 5 = 2017, Age 7 = 2019 and Age 9 = 2021. Source: National Educational Panel Study (NEPS) Newborn Cohort, own calculations.

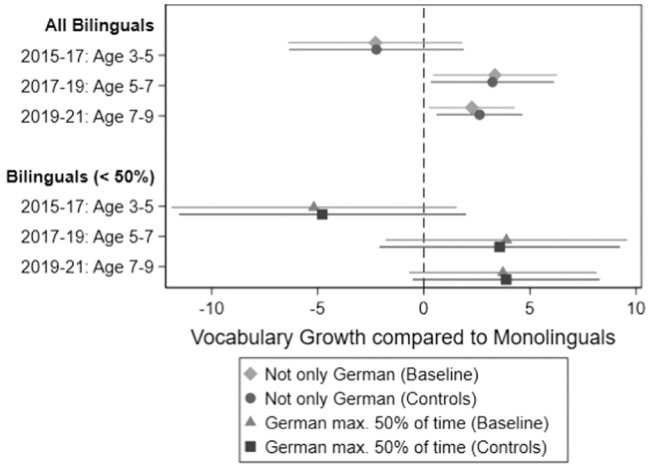

Fig. 2. Weighted coefficients for the interaction of age and bilingual status for Model 1–4, measuring the differences in vocabulary growth compared to monolinguals. "All Bilinguals" are defined as children from families in which another language is spoken (either as only language or in addition to German). "Bilinguals (< 50 %)" are defined as children from families in which another language is spoken at least half of the time (either as only language or in addition to German). Source: National Educational Panel Study (NEPS) Newborn Cohort, own calculations.

status (bilinguals vs. monolinguals) shows no significant deficit in the vocabulary growth of bilingual children compared to their monolingual peers at any age. In fact, the results reveal a notable catch-up among bilingual children between 2019 and 2021. The magnitude of the interaction effect in the model with controls means $\hat{\beta} = 2.62$ more solved vocabulary items (95 % CI = 0.59 – 4.65, $P = 0.011$), which is equivalent to 15 % of a standard deviation of the overall vocabulary distribution in 2021. It is quite remarkable that this effect occurs in 2021, shortly after the school closures, even though the wide confidence intervals suggest considerable uncertainty in the point estimate. If we redefine the group of bilinguals to a stricter variant of children from homes, in which German is spoken half of the time at most, we cannot find any significant differences in vocabulary growth. In both definitions of bilinguals, we can further observe a trend of narrowing vocabulary gains, even in 2021 after the school closures. Yet, one must be cautious about the interpretation of this finding as it could be due to possible ceiling effects in the group of monolinguals. Fig. 2 shows the interaction coefficients from the analyses using alternative baseline categories for the year to model the growth of vocabulary by group from one measurement point to the next.

As a check for robustness, we repeated our analysis with a focus on migration background (defined by the parental country of birth) instead of family language (see Fig. 3 and Table A5). Here, we differentiate between the second migration generation (both parents born abroad), interethnics (one parent born abroad) and the third generation (both parents born in Germany and at least one grandparent born abroad). Due to varied constellations of family languages (see Table A2 in the appendix), we expect dissimilar vocabulary trajectories between these generation statuses. Again, according to the results there seems to be no significant difference in vocabulary growth between children with and without migration background. However, the trend also points to a nearly significant catch-up by the second generation and interethnics during school closures, which misses the significance mark only by a margin ($P = 0.057$ for the former and $P = 0.072$ for the latter). The third migration generation does not seem to differ from its peers without migration background in its vocabulary and shows no visible trend over time.

The differences in vocabulary growth by highest parental education reveal a different pattern: higher parental education is generally associated with greater gains in vocabulary, especially at the early stage from age three to age five (see Fig. 4 and Table A6 in the appendix). Yet, the differences for age nine in 2021 (shortly after the end of school closures) are not significant, when comparing the tertiary degree as the highest parental education to the intermediate secondary degree or lower without control variables. Again, the gaps do not seem to widen significantly in the aftermath of the pandemic related school closures. In fact, there is a minor trend pointing towards slightly reducing gaps in vocabulary growth.

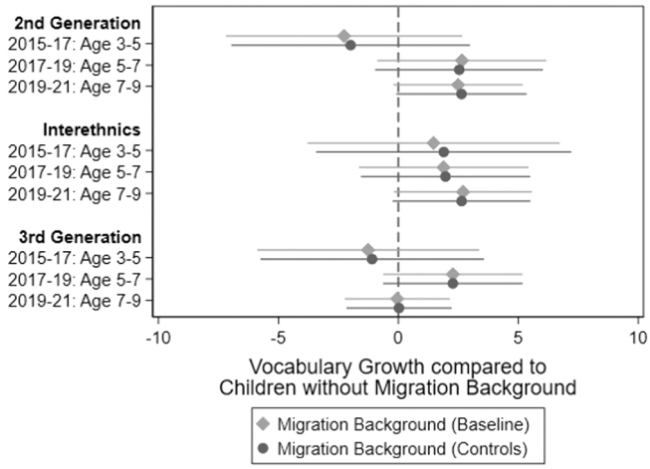

Fig. 3. Weighted coefficients for the interaction of age and migration background for Model 5 and 6, measuring the differences in vocabulary growth compared to children without migration background. Children are considered second generation if both their parents are born abroad. Interethnics are defined children with one foreign born parent and one native parent. If there is at least one grandparent born abroad, children are grouped into the third generation. Source: National Educational Panel Study (NEPS) Newborn Cohort, own calculations.

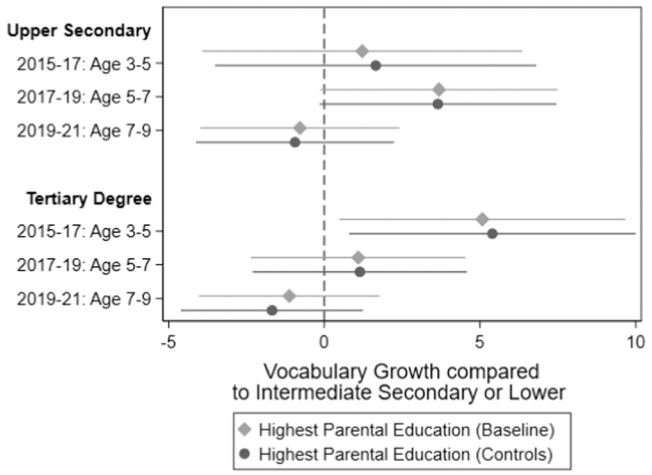

Fig. 4. Weighted coefficients for the interaction of Age and Parental Education for Model 7 and 8, measuring the Differences in Vocabulary Growth compared to children from families where an Intermediate Secondary Education Degree or Lower is the highest Educational Certificate in the Family. Source: National Educational Panel Study (NEPS) Newborn Cohort, own calculations.

These results suggest that the German vocabulary gap between monolingual and bilingual children did not increase during the time of school closures. Contrary to our theoretical expectation, the vocabulary development trajectories of both groups demonstrated remarkable stability, with the descriptive average gaps between the mono- and bilinguals remaining nearly unchanged over time. This stability persisted even after adjusting for potential confounders (e.g. access to emergency daycare services and the feasibility of parental home office arrangements). Moreover, the findings indicate a modest reduction in the vocabulary achievement gap between monolingual and bilingual primary school students. Consequently, our findings do not support research hypothesis two, in which we anticipated a widening of the vocabulary gap as a result of school closures. Furthermore, we could not find evidence for a significant widening of the vocabulary gap by migration background in 2021 or by parental education in 2021. Taken together, our results support the documented resilience of receptive vocabulary skills to temporary disruptions in language exposure, providing evidence for the third hypothesis: receptive vocabulary growth remained stable during the period of school closures in Germany.

6. Discussion

In this paper, we compared the average German vocabulary trajectories of mono- and bilingual children during the unprecedented period of school closures in Germany. Derived from the theory of language acquisition by Esser (2006), we hypothesized that the COVID-19 lockdown would impair the language growth of children in general by significantly limiting opportunities for German language instruction by professional teachers. We anticipated this effect to be more pronounced for children who do not solely speak German at home and therefore experience a comparatively reduced share of German language exposure. Accordingly, we assumed that the shift in language exposure from a structured educational setting to potentially less German-dominant home environments for bilingual children would lead to a widening disparity in vocabulary growth between bilingual and monolingual children, with the former group facing greater challenges in maintaining or enhancing their German language skills. Furthermore, we have situated our theoretical expectations in relation to initial evidence on vocabulary development during school closures and established findings from summer learning gap research.

In our first hypothesis, we expected a decline in mono- and bilinguals' competencies due to the lack of high-quality German language instruction in school during the time of school closures. In fact, we find a rather marginal slowdown in both groups, which does not seem to be particularly unusual given the similar trajectory of the age representative means provided by the norming sample. These results point to a more natural vocabulary growth deceleration, such as a ceiling effect, among other factors. By applying linear mixed models, we found a small but significant catch-up of bilinguals in the courses of the German vocabulary trajectories compared to monolinguals. When using a stricter definition for bilinguals, the catch-up effect disappears and there seems to be no significant difference in vocabulary growth between mono- and bilinguals. Therefore, we cannot confirm our second research hypothesis of growing vocabulary gaps post-lockdown but instead find support for the alternative third hypothesis, which predicted stability in vocabulary development based on previous empirical findings. Still, it is important to note that we cannot derive a full causal effect of school closures on vocabulary growth, since we are not able to measure the individual amount of school closures, as the duration and enforcement of these vary to a certain extent across German regions and municipalities (Ludewig, Schlitter, et al., 2022). As additional analyses, we examined potential differences by migration background and parental education. While we could observe a mild, albeit non-significant, trend of catching up, there was no clear evidence for a widening of the vocabulary gap between children with and without migration background. For parental education we did not find any significant differences in vocabulary growth at the times of school closures, with a minor trend of effects pointing towards a narrowing of the gap by parental education as well.

The results fit in with the mixed body of research measuring the consequences of school closures on children's competency development, which did not find growing social inequalities in every dimension (Depping et al., 2021; Förster et al., 2023). While a substantial portion of literature reports exacerbated achievement gaps during the COVID-19 pandemic, our findings align with the group of studies that did not observe significant widening in learning disparities (Förster et al., 2023; Hoffmann et al., 2024; Ludewig, Kleinkorres, et al., 2022; Sun et al., 2023).

Nevertheless, the absence of the theoretically expected loss in the German vocabulary growth across language status, migration background and parental education during the COVID-19 school closures bears a thorough discussion. In the light of the vast loss in various competence domains reported by several other (meta-)studies (e.g., Betthäuser et al., 2023; Engzell et al., 2021; König & Frey, 2022), it is crucial to contextualize our results in order to avoid trivializing the developmental consequences for children caused by school closures. First, it is important to note that our study focuses on only one facet of language competency. While our findings provide valuable insights into the receptive vocabulary domain, they do not encompass the full spectrum of language skills, such as productive vocabulary or academic language proficiency, which may have been differently impacted by the school closures. For example, research about language attrition suggests that receptive language skills such as word comprehension (as measured by the PPVT) and reading are more robust to attrition than productive language skills like speaking and writing (Jessner et al., 2021). The vocabulary seems to be even more robust to attrition than reading comprehension, as Cooper et al. (1996) showed in a meta-analytic review for competence development during the two month summer gap in the US. Moreover, the results of a study about vocabulary and reading development during the time of school closures in the US by Sun et al. (2023) resemble our findings: The vocabulary gains of all children were age-appropriate and the achievement gap between mono- and bilingual primary school children even decreased at the times COVID-19 in favor of the bilingual students, while their gains in reading comprehension decreased. The best explanation for our findings is therefore the robustness of vocabulary development to school disruptions.

In general, learning losses attributable to school closures may not uniformly affect all areas of competency development. For instance, Passaretta and Skopek (2021, 2024) found language related

competencies (vocabulary and grammar) to be more independent from school exposure than math or science regardless of students' migration backgrounds. This observation indicates that achievement gaps may not universally widen across all competence domains at the times of school closures, emphasizing the need for targeted investigations into specific areas of learning.

Another possible explanation for not finding any expected differences may lie in the distinction between general and academic language proficiency. Academic language proficiency is conceptualized as more complex and formal as well as closer to school subjects and written language (Leseman et al., 2007). Recent findings suggest that (after controlling for SES and other factors) bilingual children are more likely to have a lower academic language proficiency (Volodina et al., 2021). Hence, it is conceivable that the growth of the academic language proficiency was primarily impaired by school closures rather than the growth of the general receptive vocabulary as measured in our study. Therefore, a focused investigation into post-pandemic academic language skills could reveal more distinct disparities between mono- and bilingual children, providing valuable insights into targeted support measures. Even though the Peabody Picture Vocabulary Test used in this study yields reliable results in general receptive vocabulary, a longitudinal study with another receptive vocabulary test (possibly tailored for bilingual children) would offer valuable insights for comparisons (see Treffers-Daller, 2018 for a thorough discussion on the matter of measuring bilingual's verbal abilities).

What is more, our study has limitations, which possibly add their part in explaining our results. In our analysis we assume that the quantity of language exposure at home is roughly the same for all children, which is a crucial premise for the assertion that bilingual children experience a relative reduction in German language exposure. Despite our robust methodological framework, the inability to control for every intervening variable such as the potentially compensating role of neighborhoods between pre-pandemic (2019) and post-pandemic (2021) language assessments introduces potential for unaccounted influences. While we are not aware of any evidence suggesting systematic differences in exposure to school closures between our studied groups, the potential for such variation remains an additional limitation, although studies from the US and Chile suggest, that regions with low SES, higher shares of minority groups and low language proficiency of students reopened significantly later than other districts (Haderlein et al., 2021; Kuzmanic et al., 2023; Parolin & Lee, 2021). Without any precise individual or aggregated data on the duration of school closures, we cannot establish a causal relationship between school closures and vocabulary development. Instead, our analysis focused on the trajectories of vocabulary acquisition with an emphasis on growth differences and the comparison to growth prior to school closures.

Methodologically, it is important to note the relatively small sample size within our group of bilinguals. Although we used weights to tackle the problem of selective panel attrition, the combination of low case numbers and weights may inflate standard errors, thereby increasing the likelihood of non-significant coefficients. Furthermore, weights can only compensate for the social selectivity of cases included in the sample. In the tenth year of a large-scale panel study, it is most likely that children, who are socially disadvantaged across a whole range of characteristics such as socio-economic status, home learning environment, area of residence or competence development, already left the panel or did not even participate in the first wave. Hence, with the results of this study we cannot reliably make assumptions about vocabulary growth of children with multiple developmental and socio-economic disadvantages. A last note on our sample composition relates to the share of newly arrived immigrants and refugees: Since the NEPS Newborn Cohort was drawn in 2012 without any additional refreshment, our sample does not include children who immigrated to Germany after 2012, e.g. children from Syrian refugee families who mostly arrived 2015 or later. Comparisons of our results to cross-sectional studies on competence loss during the time of school closures including refugees or newly arrived immigrants are therefore barely feasible. Thus, further research is needed to longitudinally and causally establish the relationship between vocabulary growth of mono- and bilingual children and the school closures 2020 and2021, possibly using a sample including more children from disadvantaged background or refugee families.

Lastly, our group of bilinguals consists to a large degree of children that still speak (mostly) German at home in addition to another language. This suggests only a marginal reduction in their exposure to German, potentially diluting the expected impact of school closures on their German vocabulary development. We therefore extended our analysis to include only a subset of bilingual children who engage with another language at home as frequently as, or more than, German. However, we could not find any largely deviating results in these extended analyses which we conducted using this stricter operationalization as a robustness check (see Fig. 2). Unfortunately, we cannot measure either the child's or the parents' proficiency in the non-German language to draw conclusions about the fluency of bilingualism. Additionally, we have no information about parents' German proficiency and are consequently only able to infer conclusions about the relative quantity instead of the quality of German language exposure, which is a subject for future research.

Despite these shortcomings, this paper is the first representative longitudinal study of German bilingual vocabulary growth during COVID closures and contributes to the existing body of literature for the following reasons. To the best of our knowledge, this is the first study to focus on bilingual children with a large-scale data set to show that there is no evidence for a widening of the average German vocabulary gap between mono- and bilinguals during the COVID-related school closures in 2020 and 2021. These insights are highly relevant, as language is a central mechanism for the explanation of ethnic educational inequalities. Moreover, we could not find a significant widening of vocabulary development by migration background or parental education either. While these results were not theoretically anticipated, they may point to the conclusion that vocabulary acquisition proves to be more robust to attrition and temporal loss of exposure than other academic competencies like reading, science or math. However, gaps in vocabulary development appear to be strongly consistent over time and therefore point to the persistence of socially stratified achievement gaps by language status, migration background and parental education.

Again: Although we do not find evidence for growing achievement gaps in vocabulary during the times of school closures, we want to caution against trivializing the detrimental impact of school closures on children's socio-emotional and cognitive development. There is a large body of research providing evidence in support of the school closures' adverse influence. Instead, we present empirical support for the robustness of receptive vocabulary acquisition which proves to be the best explanation, as other studies point to similar results (Cooper et al., 1996; Sun et al., 2023). It appears that not all competence domains were negatively affected by the school closures to the same degree. The results therefore underscore the importance of nuanced analysis in understanding differential impacts of school closures across distinct competency domains and meaningful subgroups for upcoming research.

CRediT authorship contribution statement

Christian Lohmann: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Formal analysis, Conceptualization. **Teresa Haller:** Writing – review & editing, Writing – original draft, Conceptualization.

Research ethics

Our study adheres to the ethical guidelines of the German National Educational Panel Study, ensuring full compliance with all regulations governing the use and analysis of their data.

Declaration of Competing Interest

The authors declare no conflict of interest.

APPENDIX

Table A1
Descriptive statistics of panel dropouts

	In Sample		Language Status of Dropouts	
	No	Yes	Monolinguals	Bilinguals
Number of Cases	2231 (64 %)	1250 (36 %)	1394 (63 %)	834 (37 %)
Family Language[1]	***		***	
Only German	1394 (63 %)	1018 (81 %)	1394 (100 %)	0 (0 %)
Mostly German	378 (17 %)	144 (12 %)	0 (0 %)	378 (45 %)
Mostly other Language	321 (14 %)	68 (5 %)	0 (0 %)	321 (38 %)
Only other Language	135 (6 %)	20 (2 %)	0 (0 %)	135 (16 %)
Generation Status	***		***	
No Migration Background	1084 (49 %)	829 (66 %)	1074 (77 %)	10 (1 %)
2nd Generation	605 (27 %)	127 (10 %)	48 (3 %)	556 (67 %)
Interethnics	261 (12 %)	123 (10 %)	96 (7 %)	163 (20 %)
3rd Generation	281 (13 %)	171 (14 %)	176 (13 %)	105 (13 %)
Highest Parental Education	***		***	
Intermediate Secondary or Lower	781 (35 %)	178 (14 %)	463 (33 %)	316 (38 %)
Upper Secondary	602 (27 %)	294 (24 %)	304 (22 %)	298 (36 %)
Tertiary Degree	833 (38 %)	775 (62 %)	624 (45 %)	209 (25 %)
Highest ISEI in Family	57 (21)***	68 (16)	60 (20)***	52 (22)
Number of Inhabitants in Residential Area			***	
Below 100 000	240 (11 %)	96 (8 %)	186 (13 %)	54 (6 %)
100 000–500 000	757 (34 %)	424 (34 %)	471 (34 %)	285 (34 %)
500 000 or more	1234 (55 %)	730 (58 %)	737 (53 %)	495 (59 %)

[1]In the first wave, household language was assessed without the category "Equally often German and other Language". Three cases have a missing family language value.

Table A2
Family language by generation status

	No Migration Background	2nd Generation	Interethnics	3rd Generation	Total
Number of Cases	829 (66 %)	127 (10 %)	123 (10 %)	171 (14 %)	1250 (100 %)
Family Language					
Only German	797 (96 %)	18 (14 %)	61 (50 %)	133 (78 %)	1009 (81 %)
Mostly German	31 (4 %)	64 (50 %)	53 (43 %)	36 (21 %)	184 (15 %)
Both Languages equally often	0 (0 %)	11 (9 %)	6 (5 %)	2 (1 %)	19 (2 %)
Mostly other Language	1 (0 %)	29 (23 %)	3 (2 %)	0 (0 %)	33 (3 %)
Only other Language	0 (0 %)	5 (4 %)	0 (0 %)	0 (0 %)	5 (0 %)

Notes: Numbers are unweighted. Data from analysis sample in the year 2021. Frequencies are provided with percentages in parentheses. Source: National Educational Panel Study (NEPS) Newborn Cohort, own calculations.

Table A3
Results of mixed-effects regression for bilinguals in general

	M1	M2
Vocabulary Growth since Age 7 (2019)		
Age 3 (2015)	−90.48***	−91.00***
	(0.83)	(0.84)
Age 5 (2017)	−36.63***	−36.70***
	(0.55)	(0.55)
Age 9 (2021)	26.00***	25.07***
	(0.47)	(0.80)
Bilingual (ref. Monolingual)	−12.47***	−6.65***
	(1.46)	(1.55)
Interaction: Vocabulary Growth x Bilingual		
Age 3 (2015) x Bilingual	−1.06	−0.99
	(2.00)	(2.02)
Age 5 (2017) x Bilingual	−3.35*	−3.24*
	(1.49)	(1.48)
Age 9 (2021) x Bilingual	2.26*	2.62*
	(1.04)	(1.03)

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Table A3 (*continued*)

	M1	M2
Generation Status (ref. No MB)		
2nd Generation		−8.18*
		(1.90)
Interethnics		−2.53
		(1.31)
3rd Generation		1.06
		(1.20)
Highest ISEI in Family		0.08*
		(0.03)
Highest Parental Education (ref. Interm. Secondary or Lower)		
Upper Secondary		0.95
		(1.34)
Tertiary Degree		4.39**
		(1.40)
Home Office (once a Month or more)		1.68*
		(0.78)
Emergency Childcare		−0.80
		(0.79)
Child's Gender: Female		−3.13***
		(0.78)
Number of Siblings in HH		−1.53**
		(0.49)
Number of Inhabitants in Residential Area (ref. below 100 000)		
100 000–500 000		2.58
		(1.53)
500 000 or more		3.31*
		(1.47)
Increased use of Learning Videos in 2021		0.40
		(0.97)
Frequency of Joint Reading with Parent (ref. once a week or less)		
Multiple times a week		−2.31*
		(0.98)
Once daily		−1.15
		(0.99)
Multiple times daily		−2.89
		(2.70)
Frequency of Reading Alone (ref. once a week or less)		
Multiple times a week		0.42
		(1.38)
Once daily		1.24
		(1.33)
Multiple times daily		4.75***
		(1.30)
Number of Books in HH (ref. > 500)		
0–25		−9.74**
		(3.09)
26–100		−6.98***
		(1.41)
101–200		−4.57***
		(1.22)
201–500		−1.73
		(1.05)
Child's Frequency of Digital Media Usage (ref. less than once a week)		
Once a week		−0.10
		(1.52)
Several times a week		−0.02
		(1.25)
Daily		−0.62
		(1.27)
Intercept	149.59***	143.74***
	(0.57)	(3.01)
Number of observations	4355	4355

Notes: Standard Errors in Parentheses. Results are weighted. Monolinguals are defined as children from families in which German is the only language spoken. Bilinguals are defined as children from families in which another language is spoken (either as only language or in addition to German).

*$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.00$. M1: Unconditional model without any controls. M2: Model with controls. Source: National Educational Panel Study (NEPS) Newborn Cohort, own calculations.

Table A4
Results of mixed-effects regression for bilinguals who speak German half the time or less at home

	M3	M4
Vocabulary Growth since Age 7 (2019)		
Age 3 (2015)	−90.67***	−91.19***
	(0.77)	(0.78)
Age 5 (2017)	−37.11***	−37.17***
	(0.53)	(0.53)
Age 9 (2021)	26.26***	25.47***
	(0.42)	(0.76)
Bilingual w. < 50 % German (ref. Monolingual)	−22.13***	−12.20***
	(3.16)	(3.13)
Interaction: Vocabulary Growth x Bilingual (< 50 %)		
Age 3 (2015) x Bilingual	1.29	1.21
	(4.12)	(4.13)
Age 5 (2017) x Bilingual	−3.90	−3.58
	(2.91)	(2.90)
Age 9 (2021) x Bilingual	3.73	3.88
	(2.26)	(2.25)
Generation Status (ref. No MB)		
2nd Generation		−9.60***
		(1.66)
Interethnics		−4.92***
		(1.27)
3rd Generation		−0.03
		(1.18)
Highest ISEI in Family		0.08*
		(0.03)
Highest Parental Education (ref. Interm. Secondary or Lower)		
Intermediate Secondary or Lower		−4.25**
		(1.40)
Upper Secondary		−3.37***
		(1.00)
Home Office (once a Month or more)		1.58*
		(0.78)
Emergency Childcare		−0.83
		(0.79)
Child's Gender: Female		−3.43***
		(0.78)
Number of Siblings in HH		−1.52**
		(0.47)
Number of Inhabitants in Residential Area (ref. below 100 000)		
100 000–500 000		2.38
		(1.52)
500 000 or more		3.34*
		(1.45)
Increased use of Learning Videos in 2021		0.49
		(0.96)
Frequency of Joint Reading with Parent (ref. once a week or less)		
Multiple times a week		−2.13*
		(0.98)
Once daily		−0.88
		(0.99)
Multiple times daily		−2.67
		(2.71)
Frequency of Reading Alone (ref. once a week or less)		
Multiple times a week		0.66
		(1.36)
Once daily		1.47
		(1.32)
Multiple times daily		4.77***
		(1.27)
Number of Books in HH (ref. > 500)		
0–25		−10.17***
		(3.04)
26–100		−7.09***
		(1.42)
101–200		−4.68***
		(1.21)
201–500		−1.86
		(1.06)
Child's Frequency of Digital Media Usage (ref. less than once a week)		

(*continued on next page*)

Table A4 (*continued*)

	M3	M4
Once a week		0.03
		(1.52)
Several times a week		−0.35
		(1.25)
Daily		−0.69
		(1.28)
Intercept	148.20***	147.86***
	(0.54)	(3.34)
Number of observations	4355	4355

Notes: Standard Errors in Parentheses. Results are weighted. Monolinguals are defined as children from families in which German is spoken mostly or as only language. Bilinguals are defined as children from families in which another language is spoken at least half of the time (either as only language or in addition to German). *p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.00. M3: Unconditional model without any controls. M4: Model with controls. Source: National Educational Panel Study (NEPS) Newborn Cohort, own calculations.

Table A5
Results of mixed-effects regression by migration background

	M5	M6
Vocabulary Growth since Age 7 (2019)		
Age 3 (2015)	−90.19***	−90.64***
	(0.90)	(0.91)
Age 5 (2017)	−36.51***	−36.57***
	(0.64)	(0.64)
Age 9 (2021)	25.94***	25.09***
	(0.52)	(0.84)
Generation Status (ref. No MB)		
2nd Generation	−17.64***	−8.22***
	(2.10)	(2.25)
Interethnics	−5.68***	−2.24
	(1.56)	(1.63)
3rd Generation	0.48	1.86
	(1.47)	(1.35)
Interaction: Vocabulary Growth x Generation Status		
Age 3 (2015) x 2nd Generation	−0.38	−0.54
	(2.69)	(2.71)
Age 3 (2015) x Interethnics	−3.35	−3.86
	(2.77)	(2.79)
Age 3 (2015) x 3rd Generation	−1.02	−1.18
	(2.27)	(2.28)
Age 5 (2017) x 2nd Generation	−2.65	−2.54
	(1.80)	(1.79)
Age 5 (2017) x Interethnics	−1.88	−1.97
	(1.81)	(1.81)
Age 5 (2017) x 3rd Generation	−2.27	−2.27
	(1.48)	(1.49)
Age 9 (2021) x 2nd Generation	2.49	2.63
	(1.38)	(1.38)
Age 9 (2021) x Interethnics	2.69	2.64
	(1.47)	(1.47)
Age 9 (2021) x 3rd Generation	−0.05	0.03
	(1.12)	(1.12)
Bilingual (ref. Monolingual)		−6.89***
		(1.37)
Highest ISEI in Family		0.08*
		(0.03)
Highest Parental Education		
(ref. Interm. Secondary or Lower)		
Upper Secondary		0.98
		(1.34)
Tertiary Degree		4.44**
		(1.40)
Home Office (once a Month or more)		1.66*
		(0.78)
Emergency Childcare		−0.93
		(0.79)
Child's Gender: Female		−3.11***
		(0.78)
Number of Siblings in HH		−1.52**
		(0.49)
Number of Inhabitants in Residential Area		
(ref. below 100 000)		
100 000–500 000		2.60

(*continued on next page*)

Table A5 (*continued*)

	M5	M6
		(1.53)
500 000 or more		3.32*
		(1.47)
Increased use of Learning Videos in 2021		0.39
		(0.97)
Frequency of Joint Reading with Parent (ref. once a week or less)		
Multiple times a week		−2.28*
		(0.98)
Once daily		−1.12
		(0.99)
Multiple times daily		−2.83
		(2.69)
Frequency of Reading Alone (ref. once a week or less)		
Multiple times a week		0.41
		(1.38)
Once daily		1.23
		(1.33)
Multiple times daily		4.75***
		(1.30)
Number of Books in HH (ref. > 500)		
0–25		−9.74**
		(3.09)
26–100		−6.97***
		(1.42)
101–200		−4.57***
		(1.22)
201–500		−1.73
		(1.05)
Child's Frequency of Digital Media Usage (ref. less than once a week)		
Once a week		−0.13
		(1.52)
Several times a week		−0.04
		(1.25)
Daily		−0.65
		(1.27)
Intercept	149.45***	143.68***
	(0.64)	(3.03)
Number of observations	4355	4355

Notes: Standard Errors in Parentheses. Results are weighted. Monolinguals are defined as children from families in which German is the only language spoken. Bilinguals are defined as children from families in which another language is spoken (either as only language or in addition to German).
*p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.00. M5: Unconditional model without any controls. M6: Model with controls. Source: National Educational Panel Study (NEPS) Newborn Cohort, own calculations.

Table A6
Results of mixed-effects regression highest parental education

	M7	M8
Vocabulary Growth since Age 7 (2019)		
Age 3 (2015)	−85.45***	−85.73***
	(1.95)	(1.96)
Age 5 (2017)	−35.71***	−35.77***
	(1.64)	(1.64)
Age 9 (2021)	27.31***	26.88***
	(1.39)	(1.47)
Highest Parental Education (ref. Interm. Secondary or Lower)		
Upper Secondary	5.13**	3.25
	(1.93)	(1.77)
Tertiary Degree	13.15***	6.49***
	(1.73)	(1.74)
Vocabulary Growth x Highest Parental Education		
Age 3 (2015) x Upper Secondary	−4.90*	−5.30*
	(2.49)	(2.49)
Age 3 (2015) x Tertiary Degree	−6.16**	−6.54**
	(2.18)	(2.18)
Age 5 (2017) x Upper Secondary	−3.68	−3.65
	(1.95)	(1.94)
Age 5 (2017) x Tertiary Degree	−1.09	−1.14
	(1.76)	(1.76)
Age 9 (2021) x Upper Secondary	−0.78	−0.94

(*continued on next page*)

Table A6 (*continued*)

	M7	M8
	(1.64)	(1.62)
Age 9 (2021) x Tertiary Degree	−1.13	−1.68
	(1.48)	(1.49)
Bilingual (ref. Monolingual)		
Bilingual		−6.95***
		(1.37)
Generation Status (ref. No MB)		
2nd Generation		−8.12***
		(1.89)
Interethnics		−2.48
		(1.31)
3rd Generation		1.04
		(1.20)
Highest ISEI in Family		0.07*
		(0.03)
Home Office (once a Month or more)		1.61*
		(0.82)
Emergency Childcare		−0.75
		(0.79)
Child's Gender: Female		−3.10***
		(0.78)
Number of Siblings in HH		−1.60***
		(0.48)
Number of Inhabitants in Residential Area (ref. below 100 000)		
100 000–500 000		2.57
		(1.53)
500 000 or more		3.30*
		(1.47)
Increased use of Learning Videos in 2021		0.34
		(0.97)
Frequency of Joint Reading with Parent (ref. once a week or less)		
Multiple times a week		−2.29*
		(0.98)
Once daily		−1.15
		(0.99)
Multiple times daily		−2.81
		(2.68)
Frequency of Reading Alone (ref. once a week or less)		
Multiple times a week		0.43
		(1.37)
Once daily		1.27
		(1.33)
Multiple times daily		4.79***
		(1.29)
Number of Books in HH (ref. > 500)		
0–25		−9.68**
		(3.07)
26–100		−7.00***
		(1.41)
101–200		−4.58***
		(1.22)
201–500		−1.74
		(1.06)
Child's Frequency of Digital Media Usage (ref. less than once a week)		
Once a week		−0.11
		(1.52)
Several times a week		−0.01
		(1.25)
Daily		−0.60
		(1.27)
Intercept	137.66***	142.27***
	(1.63)	(3.22)
Number of observations	4355	4355

Notes: Standard Errors in Parentheses. Results are weighted. Monolinguals are defined as children from families in which German is the only language spoken. Bilinguals are defined as children from families in which another language is spoken (either as only language or in addition to German).
*p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.00. M7: Unconditional model without any controls. M8: Model with controls. Source: National Educational Panel Study (NEPS) Newborn Cohort, own calculations.

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