Running Head: PREDICTORS OF VOCABULARY AT TWO YEARS OF AGE

Early vocabulary in relation to gender, bilingualism, type and duration of childcare

Abstract

This study investigates the predictive value of child-related and environmental characteristics for early lexical development. The German productive vocabulary of 51 two-year-olds (27 girls) assessed via parental report was analyzed taking children's gender, the type of early care they experienced, and their mono- vs. bilingual language composition into consideration. The children were from an educationally homogeneous group of families and state regulated daycare facilities with high structural quality. All investigated subgroups exhibited German vocabulary size within the expected normative range. Gender differences in vocabulary composition, but not in size, were observed. There were no general differences in vocabulary size or composition between the two care groups. An interaction between the predictors gender and care arrangement showed that girls without regular daycare experience before the age of two years had a somewhat larger vocabulary than all other investigated subgroups of children. The vocabulary size of the two-year-old children in daycare correlated positively with the duration of their daycare experience prior to testing. The small subgroup of bilingual children investigated exhibited slightly lower but still normative German expressive vocabulary size and a different vocabulary composition compared to the monolingual children. This study expands current knowledge about relevant predictors of early vocabulary. It shows that in the absence of educational disadvantages the duration of early daycare experience of high structural quality is positively associated with vocabulary size, but also points to the fact that environmental characteristics, such as type of care, might affect boys' and girls' early vocabulary in different ways.

Keywords: vocabulary acquisition; language development; early childhood education; ELAN; bilingual development; gender similarities

Introduction

Early vocabulary acquisition is influenced by complex interactions of biological, socio-economic and learning factors (Gervain & Mehler, 2010; Stokes & Klee, 2009). They often affect both quality and quantity of the language input children receive (Bohman, Bedore, Peña, Mendez-Perez, & Gillam, 2009; Hammer et al., 2012; Harris, Golinkoff & Hirsh-Pasek, 2010; Hart & Risley, 2003; Hoff, 2006; Rohacek, Adams, & Kisker, 2010). Vocabulary size is highly predictive for further language development (Fernald & Marchman, 2012; Lee, 2011; Marchman & Fernald, 2008) and it is also considered an important predictor for later educational success (Walker, Greenwood, Hart, & Carta, 1994; for a meta-analysis regarding bilingual immigrant children see Prevoo, Malda, Mesman, & IJzendoorn, 2015). Early vocabulary is thus relevant when assessing developmental trajectories and risks (Henrichs et al., 2011; Lee, 2011, Ullrich & von Suchodoletz, 2011). Frequently discussed environmental characteristics influencing early vocabulary include type and quality of care (e.g. Rodriguez & Tamis-LeMonda, 2011; Ebert et al., 2013), interaction patterns of caregivers that might differ according to the child's gender (Johnson, Caskey, Rand, Tucker, & Vohr, 2014; Lovas, 2011; Sung, Fausto-Sterling, Coll, & Seifer, 2013), and the mono- or multilingual composition of the language input children receive (e.g. Byers-Heinlein, 2013; Quiroz, Snow, & Zhao, 2010). In this study, we assessed the predictive value of gender, type and duration of early care, and monolingual vs. bilingual family environment for the size and composition of two-year-olds' German expressive vocabulary.

Biological sexes and socially constructed genders have been discussed with regard to both, presumed differences in language acquisition capacity or speed (Berglund, Eriksson, & Westerlund, 2005; Bornstein, Hahn, & Haynes, 2004; Hollier et al., 2013; Leaper & Smith, 2004) and systematically differing interaction patterns of adult caregivers' speech directed at (baby)

boys and girls (Johnson et al., 2014; Lovas, 2011; Sung et al., 2013). Contrary to popular perception, the child's gender usually only explains about 1% to 3% of reported variance in vocabulary size or related variables (Ardila, Rosselli., Matute, & Inozemtseva, 2011; Szagun, Steinbrink, Franik & Stumper, 2006; for a review see Hyde, 2014). This makes gender differences likely to be detectable in large samples only (e.g. Berglund et al., 2005; Bornstein et al., 2004; Leaper & Smith, 2004), but even a recent study that included more than 5,000 one- to six-year olds did not find reliable differences with regard to boys' and girls' language skills (Luijk et al., 2015). Thus, the existence and stability of gender differences in language acquisition patterns and/or speed, especially at an early age, is questionable.

Additionally, the direction of the found differences is often ambiguous, proclaiming advantages for boys or girls with regard to different language related abilities and at different ages (e.g. Bockmann & Kiese-Himmel, 2006; Leaper & Smith, 2004). Still, presumed and measured gender differences frequently result in separate statistical norms for boys and girls (e.g. Bockmann & Kiese-Himmel, 2006; Fenson et al., 2008). The selective relevance of children's gender in interaction with socio-economic characteristics, such as maternal education and parental stress levels, has only recently gained researchers' attention (e.g. Barbu, Nardy, Chevrot, Guellai, Glas Juhel, & Lemasson, 2105; Harwood, Vallotton, & Brophy-Herb, 2016; Vallotton et al., 2012; Zambrana, Ystrom, & Pons, 2012). Possible interactions of gender and other factors, such as characteristics of the care environment are highly relevant and under-researched. This study assesses potential gender differences in vocabulary size or composition in an educationally homogeneous population at two years of age, and further investigates whether such differences might be qualified by interactions with other environmental factors.

Studies investigating the effects of type, onset, duration, and quality of early childcare often have to deal with confounds of care quality and children's individual and family characteristics (e.g. NICHD Early Child Care Research Network, 2001; Belsky, Bell, Bradley, Stallard, & Stewart-Brown, 2007; Belsky & Pluess, 2012; National Institute of Child Health and Human Development, 2006; Sylva, Stein, Leach, Barnes & Malmberg, 2011). Within the variety of SES-related variables, parental education has been shown to have strong influence on the language input provided and thus on children's vocabulary acquisition (e.g. Hoff, 2013, but for contradictory results see also: Letts, Edwards, Sinka, Schaefer, & Gibbons, 2013; Luijk et al., 2015). Previous research has also demonstrated that the relative influence of family-related factors (e.g. parental education and parenting quality) is larger than the influence of daycare related variables (Ebert et al., 2013; Belsky et al., 2007; NICHD, 2006; Pinto, Pessanha & Ahuiar, 2013). In the last decades research has concentrated on compensatory efforts, demonstrating substantial developmental gains, specifically for disadvantaged children in high quality daycare arrangements (e.g. Magnuson, Ruhm, & Waldfogel, 2007; for reviews see Burger, 2010; Jalongo & Sobolak, 2011) or for high-quality child-caregiver interactions (Vernon-Feagnas, Bratsch-Hines, & The Family Life Project Investigators, 2013), while emphasizing the cumulative negative effects of social disadvantages (Ebert et al., 2013). We thus know that the increase in school success reported for high-quality care environments, is mediated at least in part by the high-quality language input provided specifically for children at risk due to social disadvantages (Burger, 2010; Fram, Kim, & Sinha, 2012; Pinto et al., 2013). Less well investigated is the question, whether differences in early care arrangements can be associated with differences in vocabulary acquisition in the absence of educational family disadvantages.

This study examines expressive vocabulary in a group of German-speaking two-year-old children, who are homogeneous with regard to high parental education, as well as employment status. These population characteristics enable us to assess predictors of vocabulary acquisition in the absence of explicit social and educational family related risks. Also, the children attending early daycare were recruited exclusively from state-regulated centers where the standards of early education are monitored by governmental institutions to ensure high-quality care. While our study did not directly assess quality of interaction in daycare or family settings, the structural quality of the included daycare facilities, as well as the families' educational backgrounds, were very high and indicate overall advantaged upbringing conditions. Characteristics of daycare environments differ across cultures and countries, therefore research in a German setting expands current knowledge obtained in studies conducted predominantly in Sweden, the United States, and Great Britain (e.g. Broberg, Wessels, Lamb, & Hwang, 1997; NICHD 2006; Sylva et al., 2011). In this way, our study contributes to the discussion on the influence of early center-based daycare on early German expressive vocabulary acquisition in the absence of pronounced educational disadvantages.

Children's vocabulary comprehension and production develop in exchange with the people a child interacts with. The early lexicon is thus shaped by the culture and environment that surround a child (Tardif et al., 2008). If children are regularly exposed to more than one language, their lexical abilities will develop according to the input received in each of them (e.g. Bohmann et al., 2009; De Houwer, Bornstein, & Putnick, 2014; Hoff et al., 2012; Place & Hoff, 2011; Song, Tamis-LeMonda, Yoshikawa, Kahana-Kalman, & Wu, 2011; Rinker, Budde-Spengler, & Sachse, 2016 for a reviews see Gatt & O'Toole, 2016; Sheffner Hammer et al., 2014). A small to medium vocabulary disadvantage for bilingual children has been reported

when only one language is considered and has been linked to reduction of input when the total language input is divided between two languages (Bialystok, Luk, Peets, & Yang, 2010; Cote & Bornstein, 2014; Hoff et al., 2012; Klassert, Gagarina, & Kauschke. 2014; Junker & Stockman, 2002; Quiroz et al., 2010; Thordardottir, 2011; for a review see Unsworth, 2013). Multilingual or foreign language family environments in Germany are very often confounded with specific characteristics of the social environment, including higher incidence of poverty, educational disadvantages and discrimination (e. g. Kigel, McElvany, & Becker, 2015). One recent study evaluated the early productive vocabulary in bilingual Turkish-German children aged 24 to 26 months finding much lower number of German versus Turkish items, but comparable total numbers when both languages were considered. However, the Turkish speaking parents involved displayed relatively low SES and disadvantaged educational backgrounds typical for families of Turkish descent, especially in larger German cities (Rinker, Budde-Spengler, & Sachse, 2016). Therefore, which differences between mono- and bilingual children's vocabulary do actually exist in the absense of educational disadvantages is an underresearched question with regard to German speaking children. In this study we were able to evaluate early German expressive vocabulary in a small subgroup of bilingual children who were comparable to the monolingual group with respect to the educational background and employment status of their parents.

We investigated early lexical acquisition via parental report using a vocabulary checklist. The instrument employed in this study Eltern Antworten (ELAN, Parents Responses, Bockmann & Kiese-Himmel, 2006) is a commonly used screening tool in Germany (Ullrich & von Suchodoletz, 2011), thus appropriate normative data for a standardization popualtion exist. The ELAN, just as the internationally better known MacArthur-Bates Communicative Development Inventories (CDI, Fenson et al., 2008), assess children's productive vocabulary by asking parents

(or sometimes teachers) to indicate which words of a preselected list a child speaks at a given point of time. Parental reports are directly related to language skills measured by other means, such as laboratory assessment, and are considered very reliable when identifying children at risk for language delays (Rowe, Raudenbush, & Goldin-Meadow, 2012; Ullrich & von Suchodoletz, 2011). Also, prior analyses of an extension of the current dataset indicated that ratings from two parents and from a parent and a teacher both reach high inter-rater reliability and agreement (Stolarova, Wolf, Rinker, & Brielmann, 2014).

The evidence briefly reviewed above shows that early expressive vocabulary is influenced by the interaction of a variety of factors. In this study, children's productive vocabulary at 24 months is assessed in an educationally homogeneous German-speaking group via parental report. The comprehensive statistical analysis based on mixed-effects regression models, takes random effects of child and word into consideration to control for variance in the data caused by unsystematic inter-individual and inter-word differences. In this way, the model reveals general influences of theoretically grounded predictors ("fixed effects") on the overall probability to speak any of the 250 ELAN-words. Below, the following predictors and their interactions are considered: gender of the child, type of care, mono- vs. bilingual family environment. In addition, duration of care in months and its relation to vocabulary size were investigated.

Methods

Ethics statement

All parents, the heads of the daycare centers and all daycare teachers involved in this study gave written informed consent according to the principles of the Declaration of Helsinki (see: http://www.wma.net/en/20activities/10ethics/10helsinki/) prior to participation. Special care was

taken to ensure that participants understood that their participation was voluntary and could be ended at any time without causing disadvantages to them, their children or the daycare centers.

Research instruments and procedure

Participating children and parents (n=58) were recruited from two middle size German cities and their surroundings. Parents responded to open advertisements at childcare centers (n=8) and local media. Data collection took place within a period of two days before or after a child's second birthday (M_{age}=730.20 days, SD=2.01). The number of spoken words was assessed on the basis of the German lexical checklist for parents *Eltern Antworten* (ELAN, Bockmann & Kiese-Himmel, 2006). The ELAN consists of 250 words in 17 semantic categories, derived and pre-selected from the empirically determined expressive vocabulary of German speaking children (see Supplementary materials for an excerpt of the ELAN). For each word parents need to check whether a child actively produces a certain word ("ja", German for "yes"), or does not ("nein", German for "no"). If the parents do not make a clear indication by checking one of the boxes, the answer is counted as missing value. In addition, parents provide examples of their child's utterances in a few open questions at the end and answer basic demographic questions at the beginning of the questionnaire. Study-specific parent and teacher questionnaires were also employed to collect further information on the educational and language backgrounds of the parents and teachers involved. For the purpose of the present analysis, vocabulary data provided by the parent who also answered the demographic questions (40 times the mother, 2 times both parents together, 9 times the father) are considered.

Study population

Vocabulary ratings were initially obtained for 58 two-year-old children (M_{age}=730.20 days, *SD*=2.01, 24 months ± 2 days, 32 girls). Seven data sets were excluded from analyses to guarantee high data quality and a homogenous health status of the sample. Four data sets were excluded to ensure that all data stems from a group of normative developing children without any indication for language delays or health risks (3 children with substantial risk for specific language delays, i.e., with scores < 10th percentile of the standardization population, 1 bilingual; 1 child in daycare). Data of one girl in daycare was excluded due to her premature birth prior to the 26th week of gestation. Two data sets were excluded due to more than five missing answers (< 2% of items) on the vocabulary checklist. Lastly, one child was excluded because he had started daycare only 2 months prior to testing and could not be assigned to either of the two care comparison groups (see below). Thus, data provided by parents of 51 children (27 girls) were included in the analyses.

At the time of testing, 32 children had experienced regular non-parental, center-based care for at least six months. We will refer to these children as the *daycare group*. Weekly daycare varied between the categories *11 to 20 hours* (*N*=5) and *more than 20 hours* (*N*=27). All children attended daycare within a 5-days-a-week program. The duration of daycare experienced prior to testing at the age of two years varied between six and 22 months.

Children who were cared for exclusively by their parents (*N*=19) and had no formal daycare experience will be referred to as the *parental-care group*. Children were also included in the parental-care group if they experienced some form of irregular and informal non-parental care (e.g. playgroups or babysitters) up to a maximum of 12 hours and up to three times per

217 week. A summary of the demographic characteristics for the study population, as well as for the
218 two care subgroups is provided in **Table 1**.

219 Taking the specifics of the German educational system into account, parental education
220 levels were compared considering the highest secondary education degree obtained. The
221 category reported by the vast majority of the parents was the German university entrance
222 certificate (Abitur) or a foreign equivalent (see **Table 1**)[1]. In addition, all parents had received
223 further professional training and/or completed a higher education degree. At the time of testing,
224 mothers were either employed (33), on parental leave (17), or pursued a university degree (2).
225 All but one father were employed, the father who reported unemployment had only recently
226 moved to Germany. No parent reported current involuntary unemployment. Income distribution
227 was not assessed directly in this study. Taken together, the demographics indicate a non-
228 representative, advantaged educational background and employment status of the participating
229 families. While we did not collect specific income information from the parents, we can infer
230 about the income-situation of the families: our sample did not include involuntarily unemployed
231 parents, children below the age of three years were only admitted into state regulated daycare
232 centers at the time and place of data collection, if their parents were working or studying and
233 children cared for at home had a family income allowing one parent to stay on parental leave for
234 at least two full years after the child's birth.

235 All children actively spoke and listened to German on a daily basis. For 39 of them the
236 family environment was monolingual German (subsequently referred to as *monolingual*

[1] Federal Statistical Office (2016). The reader unfamiliar with the German educational system should note that the so called Abitur or University Entrance Certificate is regularly awarded after 12 to 13 years of schooling. It is the highest of three possible school degrees obtainable in Germany. Official statistics state that in the year 2014 28.8% of the German population had Abitur, compared to the over 80% of the parents in our study (see for example https://www.destatis.de/DE/ZahlenFakten/GesellschaftStaat/BildungForschungKultur/Bildungsstand/Tabellen/Bildungsabschluss.html)

children). In contrast, 12 children spoke another language with at least one parent (nine belonging to the daycare group, three to the parental care group). One of those children (a girl attending a whole day daycare program for more than 11 months prior to the assessment) was raised in a trilingual family environment; her parents spoke two different languages other than German with their daughter, but communicated in German with each other. We included this girl in the group of 11 other bilingual children, as she was actively producing words only in German and her mother's native language and was not yet speaking her father's native language. The small subgroup of bilingual children constitutes a convenience sample recruited along with the monolingual group.

Testing was conducted exclusively in German, all multilingual parents' demonstrated excellent understanding, speaking and reading/writing skills during testing. Due to the lack of standardized questionnaires, we were not able to collect vocabulary information for all languages spoken by our multilingual participants, but analyzed their children's German expressive vocabulary only. A summary of the bilingual children's language backgrounds and information regarding language contact distribution, as well as a detailed table on parental education in relation to multilingualism are provided in the Supplementary Online Material.

At the time of testing, child care spaces for children under the age of three years was very limited in the region of testing and only accessible to working or studying parents. This is an additional factor explaining why families of lower educational and social backgrounds, e.g. unemployed parents, are not represented in our sample (and are likely underrepresented in the younger age groups in daycare facilities in this region in general), specifically in the daycare sample. As shown in **Table 1** this non-representative SES-distribution also holds true for the parental-care group, but for reasons not systematically assessed here. One main hypothesis is the

overall higher willingness of higher educated and better-of parents to participate in voluntary research with children (for a general discussion see Heinrich, Heine, & Norenzayan,2010 or Bergstrom, Partington, Murphy, Galvao, Fayram, & Cisler, 2009).

Characteristics of the participating daycare centers and teachers

All participating daycare centers were state regulated and funded. The group size in the daycare centers varied between 9 and 20 children, the majority of children (70%) were cared for in a group with up to 10 children and at least 2 daycare teachers present at all times. A total of 24 daycare teachers primarily responsible for the participating children participated in the study and provided information on their own professional training and experience, four of them evaluated more than one child. All of the participating teachers were female native speakers of German and all of them reported regular, as well as recent participation in continuing education courses, including state regulated courses on early language acquisition. All but one daycare teacher had completed a vocational degree in early child-care, the other teacher held a degree in nursing. Even though interaction quality was not directly evaluated, teacher's vocational and further trainings, group sizes, child-to-teacher ratios and governmental funding associated with strict control of the facilities taken together indicate relatively high structural quality of non-parental care in our daycare group.

Analysis

The complete data set is openly available at https://osf.io/vi28r/, a table displaying all estimated probabilities for boys and girls, as well as mono- and bilingual children for each of the ELAN words can be accessed as spreadsheet here: https://osf.io/j69vc/, the analysis code is

provided at https://osf.io/6e58y/. The dependent variable of interest here was the score *spoken: yes (1) or no (0)* for each word of the ELAN. We used mixed-effects logistic regression models (Baayen, 2008; Baayen, Davidson, & Bates, 2008) to investigate the influence of child related and environmental factors on expressive vocabulary. In this approach, the log of the ratio (logit) of spoken to unspoken words is the response variable. It is predicted from fixed (e.g. group, gender, duration of daycare) and random-effects (child, word). Logits are equivalent to proportions, but meet the mathematical requirements of the linear model. Outcome probability is assumed to vary randomly according to random effects (here: word and child), while at the same time the fixed effects of one or more predictors are assessed. This approach is especially useful when considering small and heterogeneous subgroups and relatively large item-lists, as is the case in this study, because it modestly enhances power and takes inter-individual random variability into account.

The theoretically relevant predictors considered in this analysis were: daycare or parental-care (*Group*), male or female child (*Gender*), mono- or bilingual family environment (*Bilingual*). Continuous predictors were the education level of the father (*Education of father*) and the duration of daycare children in the daycare group had experienced (*Duration of daycare in months*). Education of the mother is also a theoretically important predictor of early vocabulary; however, we were unable to include it in this analysis, since it did not vary to a sufficient degree in the present sample (see **Table 1 and Supplementary Table S3**). Similarly, the constellation of siblings (birth order, number of siblings or number of older siblings) was not included, as no informative predictor that was sufficiently independent from other predictors could be derived for this sample. The *lmer* function of the R package *lme4* (Maechler, Bolker, & Walker, 2014) was used to conduct the analyses.

306 The best-fitting model was obtained sequentially; one cluster of predictors was added to the
307 model at a time. Likelihood ratio tests ensured that the goodness of fit improved while taking
308 costs of extra parameters into account. **Figure 1** illustrates the sequence of models applied as
309 follows: First, children (*Child*) and items (*Word*) were set as random factors for the initial model,
310 in order to account for random inter-individual and inter-word effects. Second, we explored
311 whether the random effect of Word varied according to the factorial predictors: Gender,
312 Bilingual, Group. Third, these factors Gender (reference level = female), Group (reference level
313 = parental care), and Bilingual (reference level = false) were added to the best-fitting random
314 effects model. Fourth, the continuous predictor *Education of father* (reference level = lowest
315 education) was added.

316 To test whether the expressive vocabulary of two-year-old mono- and bilingual children
317 experiencing regular daycare was predicted by the duration of daycare in months prior to data
318 collection, we conducted a separate set of analyses including the predictor *Duration* of daycare
319 in months (see gray boxes in **Fig.1**).

320 To summarize, random effects of Child and Word served to control for variance in the data
321 caused by unsystematic inter-individual and inter-word differences. Exploration of estimated
322 random intercepts for different words allowed identification of probabilities that a specific
323 ELAN word is spoken. Fixed effects revealed the general influence of the predictors considered
324 on the overall probability to speak any ELAN word.

325 To illustrate the observed fixed effects, 95% confidence intervals (CIs) for proportions
326 were calculated according to the groups of interest. The R package *PropCIs* was used to
327 calculate these CIs. To relate results obtained for probabilities via mixed-effects models to the
328 absolute number of words spoken and to the norms provided in the ELAN manual for two-year-

old boys and girls, we also calculated 95% CIs around the average number of words spoken in those subgroups of children meaningfully different according to the final mixed-effects model obtained earlier.

Results

Expressive vocabulary predictors for the entire population

The final model's estimated coefficients, their standard errors and *z*-values are displayed in **Table 2**. Collinearity was not observed between the predictors of this model, all correlations between predictors $\rho \leq .25$, and $\kappa = 8.59$ provided evidence that predictors varied independently from each other. The final model predicted the data better than the basic model which only included random effects, $\chi^2 = 22.89$, $p < .001$. In brief, children's German expressive vocabulary size at the age of two years was predicted significantly by their bi- or monolingual language acquisition environments, and by the interplay between children's gender and the type of early care they had experienced. This also means that children's gender, the type of early care they had experienced prior to testing, or their fathers' educational level did not independently improve predictions for productive vocabulary at the age of two years.

Random effect structure

The top row of **Table 2** show the random effects included in our final model. A considerable amount of variance in the probability that a particular word was rated as spoken can be attributed to differences between words, likely due to differences in difficulty and/or frequency of the words. Similarly, a high proportion of variance in the likelihood to speak any of the ELAN words was explained by inter-child variability, a likely and predictable illustration of

the high inter-individual variability in early language acquisition. All estimated probabilities of a certain word to be spoken split by gender, daycare group and bilingualism are provided as Supplementary Table. The systematic effects of the assumed and tested predictors reported below emerge and remain meaningful after statistically controlling for the random effects of word (item) and child.

Systematic differences between boys and girls were evident in a modulation of the random effect of words (as indicated by the significant term Gender|Word). That is, girls and boys differed in the probability to speak a certain word and thus in the presumed composition of their early vocabulary, but not in the general number of spoken words (see below). **Figure 2a** illustrates this difference as well as the fact that most of the 250 words of the ELAN were spoken with similar probability by boys and girls while there was large variance between words.

Bilingual and monolingual children differed with regard to the particular words they spoke (variance=271, comparison to initial model: χ^2=11.86, p=.003). **Figure 3a** shows differences and commonalities in the probabilities that individual ELAN words were spoken by mono- and bilingual children.

The fit of the model that allows the random effect for word to differ between mono- and bilingual children was not better compared to the one including Gender, χ^2=0.0, p=1. Hence, we selected the latter to continue analyses, since the gender of a child represents a more basic characteristic, and also because our sample included only a limited number of bilingual children (12) but a similar and higher number of boys and girls (27 girls and 24 boys).

Whether a child was cared for at home (parental-care group) or had regular daycare experience (daycare group) did not have a modulating effect on which words children were most and least likely to speak (see **Fig.2b**), χ^2=0.17, p=.92.

Fixed effects

In contrast to the random effects, e.g. of Word, i.e. probabilities for *individual* words to be rated as actively spoken, fixed effects identify predictors for the probability that *any* ELAN word is spoken. Thus, fixed effects refer more directly to the quantity of spoken words also known as vocabulary size. The (Intercept) estimate refers to children's average probability to speak a word at a reference level, here: girls, daycare group, monolingual, lowest education of the father. This probability decreased for bilingual children (see **Fig.3b**). The influence of Gender and Group interacted: Boys in daycare and boys in exclusively parental care did not differ from the reference group of girls in daycare, but girls in the parental care group had a somewhat larger vocabulary size than all other children (see **Fig.4**).

Effects of daycare duration

To examine the potential influence of the duration of daycare experience prior to testing on children's vocabulary, we separated the data of the children in daycare (N=32) after determination of random effects (see gray boxes in **Fig.1**). As the smaller number of children does not allow taking all available predictors into consideration without basing analyses on data of individual children, we only entered two predictors of interest: Bilingualism and Duration of daycare in months in the initial models. Again, collinearity was not observed, as the correlation between predictors was low, ρ=-.19. The final model's estimated coefficients, their standard errors and z-values are displayed in **Table 3**.

The model fit improved by adding the predictors Bilingual and Duration of daycare in months, χ^2= 243.58, p<.001, but not by including the interaction between both, χ^2= 0.03, p=.86. Thus, bilingualism and duration of daycare independently predicted expressive German

vocabulary in the daycare group. The reference group, i.e. the values from which the model calculates changes, consisted here of monolingual children with (fictive) minimal daycare duration of 0 months. With increasing time spent in daycare, the probability to speak any word increased (see **Fig.5**), such that e.g. a child having spent 12 months in daycare (the median and mean value in this sample) would have a 12% increase in productive vocabulary compared to a child having spent 6 months in daycare. Bilingualism again negatively predicted expressive German vocabulary size, such that a bilingual child experiencing regular non-parental daycare would have a decreased average probability to speak any of the German ELAN words in comparison to a monolingual child with the same daycare experience. As shown in **Figure 6** and explained below, vocabulary size of both, bilingual and monolingual children varied within the expected normative range.

Average number of words spoken and relation to ELAN norms

The final mixed-effects model obtained in our analyses showed that there are meaningful differences regarding children's probability to speak any ELAN word, an estimate of vocabulary size. **Figure 6** illustrates how these effects correspond to differences regarding the absolute number of words reported to be spoken: girls in parental care speak on average more words than all boys and girls in daycare, and bilingual children speak on average less words than monolinguals. Comparison with means and standard deviations provided in the ELAN Manual (Bockmann & Kiese-Himmel, 2006) for the standardization population of 24-month-old monolingual German boys and girls shows that the mean number of words spoken in all subgroups in this study fall within +/- 1 SD of the norm. This illustrates that all children in this study exhibited at least normative average vocabulary size. It also shows that the girls in parental

421 care, for whom a difference in vocabulary size compared to the three other groups was detected,
422 the largest vocabulary: the 95% CI surrounding the means of this group extended slightly above
423 + 1 SD of the standardization population (see **Fig.6a**).
424
425 **Discussion**
426 The main purpose of this study was to assess a series of potential predictors for expressive
427 vocabulary development in a group of two-year-old German-speaking children in two different
428 early care settings: exclusive parental-care and center-based daycare. In this way, we examined
429 whether either of these care environments is associated with specific early vocabulary
430 advantages or disadvantages. We also assessed whether boys and girls, as well as mono- and
431 bilingually raised German-speaking children differ systematically with regard to expressive
432 vocabulary size or composition. The children participating in this study came from educationally
433 homogeneous, advantaged family backgrounds. This allowed us an assessment of early
434 vocabulary in the absence of pronounced disadvantages and also diminished possible
435 confounding effects of family background and quality of early care. In addition, we restricted the
436 age range to ± 2 days around the children's second birthday and were thus able to assess
437 expressive vocabulary in a group highly homogeneous not only with regard to educational
438 background of the parents, but also to age. The use of logistic mixed-effect models allowed us to
439 analyze potential predictors of vocabulary size while controlling for differences between
440 individual children and words. At the same time, systematic variation in random effects revealed
441 meaningful divergences in the composition of vocabulary between subgroups of children.
442 Finally, we related the fixed effects in our mixed-effects model to the duration of daycare and the

absolute amounts and means of words spoken and compared the vocabulary size in our study to the normative range reported in the manual of the employed assessment tool.

Two-year-old girls and boys differed with regard to the probability to speak certain words and thus with regard to vocabulary composition (see **Fig.2a** for some examples), but exhibited very similar vocabulary sizes (see **Figs.4** and **6**). Within our group of children with homogeneously high SES, the type of early care experience was not a meaningful predictor of vocabulary size or composition (see **Figs.2b** and **4** for an illustration), but this main effect was modulated by an interaction (as discussed below). Neither exclusive parental care nor early center-based daycare settings were associated with specific disadvantages regarding children's expressive vocabulary at 24 months. Rather, we found an overall average vocabulary size across care groups, genders and for mono- and bilingually raised children. The educational level of the father did not contribute to the prediction of expressive vocabulary in our sample with relatively high average paternal education, low variability of this potential predictor, and virtually no variability of maternal education (see **Table 1**). Given that we assessed children from homogeneous family backgrounds, the absence of differences with regard to vocabulary size and composition between the groups of children with different care arrangements before the age of two years is in accordance with previous research which has demonstrated that the influence of family characteristics on language is stronger than the influence of care type (Belsky et al., 2007; NICHD, 2006; Pinto et al., 2013; Sylva et al., 2011). Future research could replicate and extend our finding by including larger and demographically more variable groups of children and by using a vocabulary assessment instrument that includes more words. For Germans this could be the FRAKIS questionnaire (Szagun, 2004), which measures productive vocabulary, sentence

complexity and length of utterance, or the ELFRA-2 (Grimm & Doil, 2000), another parent report assessment tool for expressive vocabulary, syntax and morphological skills.

The gender of the two-year-old children alone did not predict differences in vocabulary size. The possibility that effects of gender on vocabulary size or other linguistic abilities might emerge at a later age or can be detected in larger samples cannot be excluded on the basis of our results, considering the relatively small group of two-year-old children examined here. Our results are, however, in line with previous findings: If there is a (direct or indirect) gender influence on early expressive vocabulary at all, it is small. They are also consistent with recent findings reporting gender differences in language acquisition in low, but not in high SES children (Barbu et al., 2015) The expected performance overlap between genders is large, making the relevance of such presumed differences for everyday communication and early childhood education at least questionable.

In our study, an interesting interaction between gender and type of care emerged. It showed that girls cared for at home and not attending daycare before the age of two years exhibited somewhat larger vocabulary size in comparison to all other children. Yet, all subgroups of children showed an average vocabulary size (see **Fig.6**). Due to limitations regarding the size of the subgroups (only seven girls did not attend daycare), this interaction has to be interpreted with caution. Also, we cannot make any conclusive claims about the underlying reasons for these differences, but they could relate to parental communication behavior (Bohman et al., 2009; Harris et al., 2010; Hart & Risley, 2003; Hoff, 2006; Rohacek et al., 2010) and complement recent reports on differential effects of environmental variables for boys and girls (Barbu et al., 2015; Berglund et al., 2005; Vallotton et al., 2012; Zambrana et al., 2012).

Judging by structural quality characteristics, such as teacher's education background, group sizes and teacher-to-child ratios, daycare provided for our sample was likely of high quality. Researchers have argued that high-quality center based daycare is particularly beneficial for the development of socially and educationally disadvantaged children (Burger, 2010; Phillips & Morse, 2011), a group that was not assessed in this study. Nonetheless, we investigated whether vocabulary scores change according to the time children had spent in center based daycare before their second birthday (see **Fig.4**), since some studies have reported particularly beneficial effects of high-quality extensive daycare before children's first birthday on children's vocabulary up to the age of 5 years (e.g. Belsky et al., 2007). Within children attending regular state regulated daycare, we found increasing vocabulary size with increasing duration of prior daycare experience. The nature of this relation is correlational, it relies on cross-sectional data and the assignment to very early vs. later age at daycare entry is likely not random. Thus, we cannot argue that the prolonged daycare experience directly benefitted children's expressive vocabulary at the age of 2 years. In light of previous research, however, we assume that the combination of a structurally high-quality daycare environment and the possibility for regular interactions with peers as well as with trained adult caregivers (NICHD, 2006; Belsky et al., 2007) have a positive impact on children's early expressive vocabulary. Further investigations with larger and more diverse samples in longitudinal designs are needed to clarify whether and how high-quality early daycare might generally benefit vocabulary acquisition in young children, in the absence or presence of social disadvantages. Young children with multilingual and/or non-German family language environments are of particular interest in this regard.

Independent of care group, we found evidence for somewhat higher German expressive vocabulary size in monolingual compared to bilingual children. In addition, we found differences

with regard to the composition of the early German vocabulary exhibited by mono- and bilingually raised two-year-olds (see **Fig.3a** and Supplementary Table for details). The bilingual children exhibited age-appropriate German expressive vocabulary (**Fig.6)** and the differences between mono- and bilingual children were of medium size. We attribute these relatively minor differences in German expressive vocabulary between bilingual and monolingual children to overall high parental education, the absence of systematic differences in family background, mostly family environments with one German-speaking parent (10 out of 12) and the fact that 9 out of 12 bilingual children experienced regular monolingual German high-quality daycare. However, there was somewhat larger variance in parental education for bilingual compared to monolingual families in our sample. Thus, we cannot conclude to what extent the differences in average German vocabulary size of mono- and bilingual children might be attributable to the small differences in parental education or to the bilingual language acquisition itself. But we provide evidence that at the age of two years, the differences between these mono- and bilingual children in vocabulary size and composition are small and thus unlikely to have negative long-lasting effects on everyday communication and language acquisition. Future research should assess the effects of these moderate early differences longitudinally to determine whether they tend to decrease as bilingual children spend more time in monolingual educational settings.

In conclusion, we found no differences with regard to the measured predictors of early vocabulary size or composition between groups of German-speaking children attending and not attending center-based daycare before the age of two years. No general gender differences regarding expressive vocabulary size for these children from a homogeneous, well-educated family background were found either. Girls in exclusively parental care exhibited somewhat larger average vocabulary sizes, compared to all other subgroups of children, but overall all

subgroups' vocabulary size was at least average compared to the standardization population. Thus, both types of care environments seem to provide adequate levels of language input needed for successful early vocabulary acquisition under the investigated circumstances and specifically in the absence of social or educational family disadvantages. We also showed that bilingual two-year-old children exhibit slightly lower expressive vocabulary when only one language, in this case German, is considered. In our study this difference was unlikely to predict further educational disadvantages, since vocabulary size for all 12 bilingual children remained within 1 SD of the mean of the monolingual standardization population and can thus not be considered different from it. This study expands current knowledge about relevant predictors of early vocabulary. It shows that in the absence of educational disadvantages prolonged high-quality early daycare experience is associated with larger vocabulary, but also points to the fact that environmental characteristics, such as type of care, might affect boys' and girls' early vocabulary in different ways.

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Tables

Table 1.

Population characteristics.

	Total *N* (%)	Daycare *N* (%)	Parental-care *N* (%)
Total	51	32	19
Data provider mother	40 (76.9)	25 (78.1)	15 (78.9)
Female	27 (52.9)	20 (62.5)	7 (36.8)
Firstborn[a]	36 (70.6)	21 (65.6)	15 (78.9)
Bilingual	12 (23.5)	9 (28.1)	3 (15.8)
Two-parent household	44 (86.3)	25 (78.1)	19 (100)
Highest sec. education[b]: mothers	42 (82.4)	26 (81.3)	16 (84.2)
Highest sec. education[b]: fathers	38 (74.5)	24 (66.7)	14 (73.7)
Mother employed	30 (58.8)	26 (81.3)	4 (21.1)
Father employed	50 (98.0)	32 (100)	18 (94.7)

Note. Percentages in brackets are group-based (column-wise). [a]Including two pairs of firstborn twins, all four children were counted as firstborns. [b]Refers to German university entrance certificate (Abitur) or a foreign equivalent, see footnote 1 for further explanations); all parents received further professional training and/or completed a higher education degree.

Table 2.

Variance for random effects and estimates, standard errors (SEs), and z-values for fixed effects in the final model for the entire study population.

		Variance	Estimate	*SE*	*z*
Random effects	Word	3.17			
	Gender|Word	0.21			
	Child	1.94			
Fixed effects	(Intercept)		1.49	0.36	4.10***
	Gender		0.07	0.52	0.13
	Group		2.26	0.63	3.60**
	Bilingual		-1.77	0.47	-3.73***
	Group : gender		2.61	0.86	3.06***

Note. Reference levels for factors were: Gender=female, Group=daycare, Bilingual=false.

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

807 Table 3.

808 *Variance for random effects and estimates, standard errors (SEs), and z-values for fixed effects*

809 *in the final model for the daycare group.*

		Variance	Estimate	*SE*	*z*
Random effects	Word	3.31			
	Gender|Word	0.53			
	Child	1.50			
Fixed effects	(Intercept)		0.24	0.73	0.33
	Bilingual		-2.02	0.50	-4.05***
	Months in daycare		0.12	0.06	0.03*

810 *Note.* Reference levels for factors were: Gender=female, Bilingual=false. *p<.05; ***p<.001

811

Figures

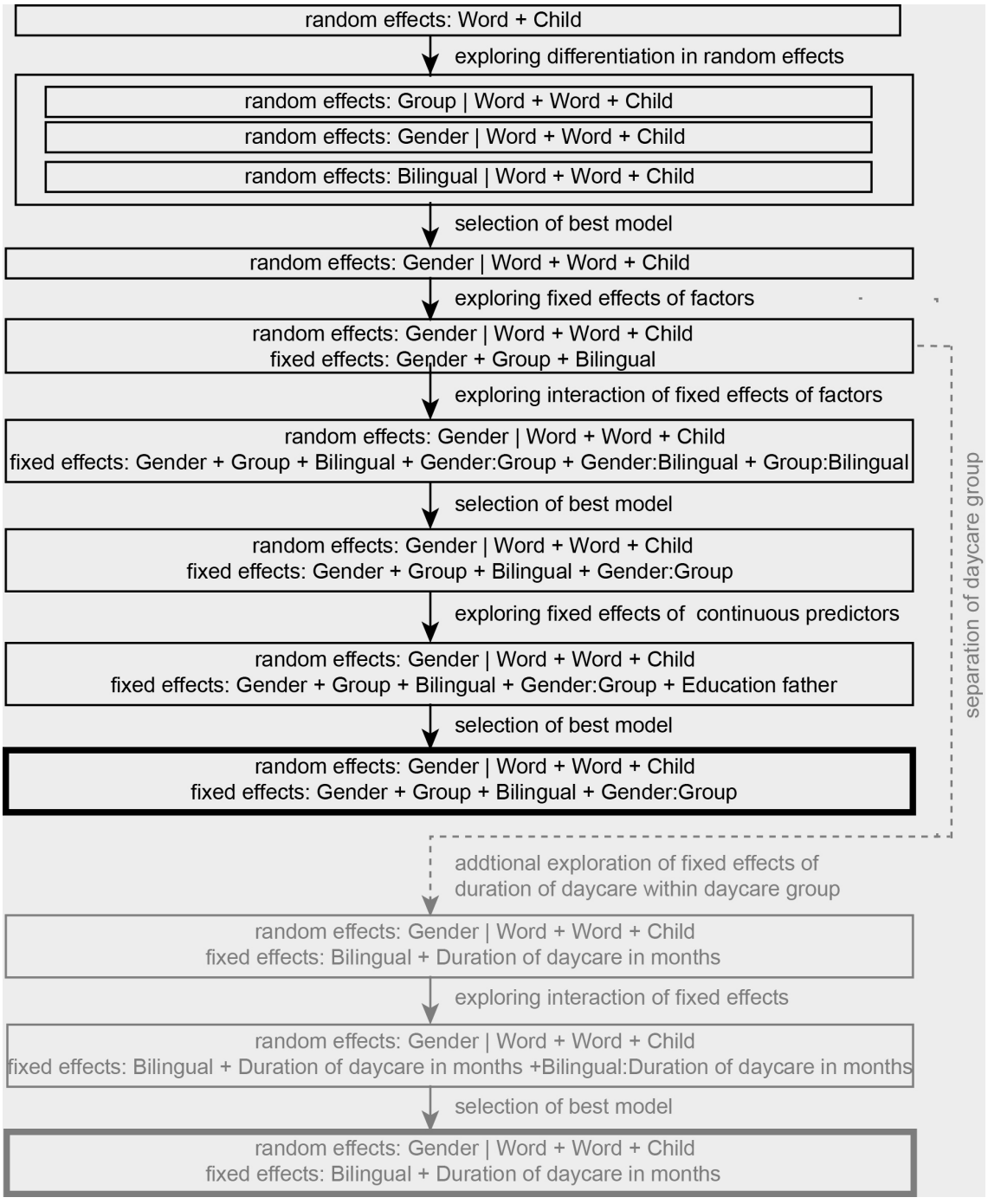


Figure 1. Flowchart displaying sequence of linear mixed models applied. Main analyses regarding the entire population are displayed in black, separate analyses for the daycare group are shown in gray. The best model was selected by removing non-significant predictors and Likelihood ratio tests.

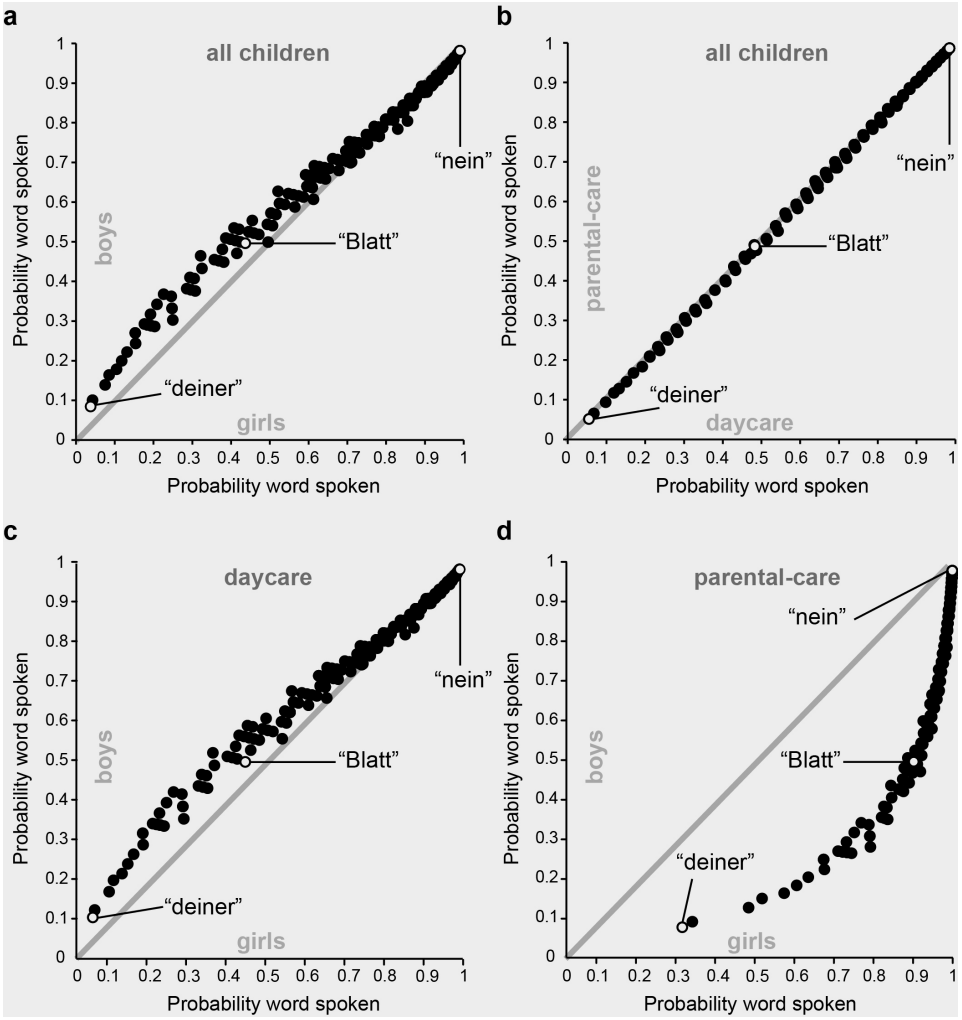
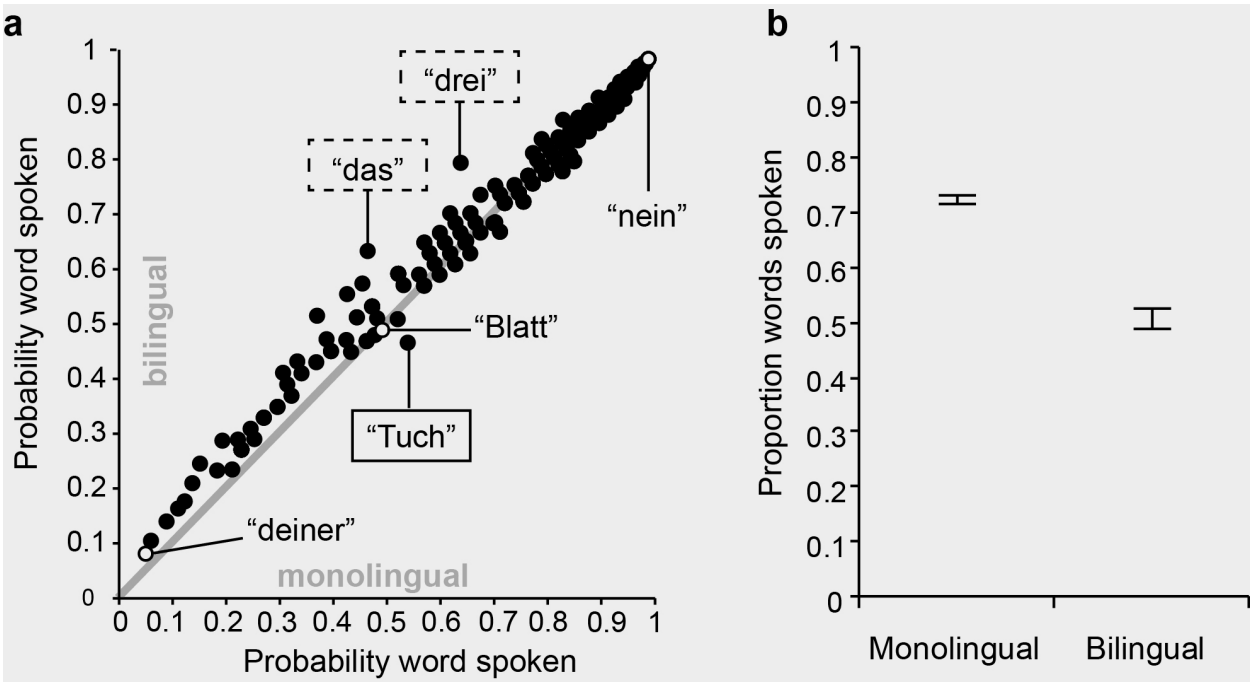


Figure 2. Probability that any ELAN word is spoken based on estimates of random effects. Estimates in the top panels were derived from the model without fixed effects and random effects for Gender|Word (a), or Group|Word (b). Estimates in the bottom panels were derived from the final model and show random effects of Gender|Word separately for children in daycare (c) and in parental-care (d). The gray line marks equal probabilities for both subgroups in each panel. Data points of reference words re-appearing at similar places throughout are filled in white. The exemplarily displayed words translate to: "deiner"=yours, "Blatt"=leaf, "nein"=no. A list for all probabilities per word is available for further analyses here https://osf.io/j69vc/.



827

828 *Figure 3.* Probability that any ELAN word is spoken based on estimates of the random effect of
829 Bilingual|Word (a) and proportions of spoken words according to the fixed effect of bilingualism
830 (b). Estimates of random effects were derived from the model without fixed effects. The gray
831 line marks equal probabilities for both subgroups in each panel. Data points of reference words
832 re-appearing at similar places throughout are filled in white. The exemplarily displayed words
833 translate to: "deiner"=yours, "Blatt"=leaf, "nein"=no. A list for all probabilities per word is
834 available for further analyses and is accessible here: https://osf.io/j69vc/. Error bars in (b) denote
835 95% CIs for proportions.

836

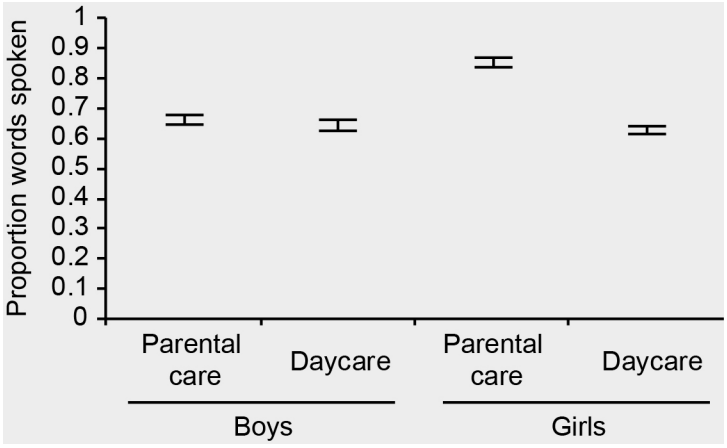
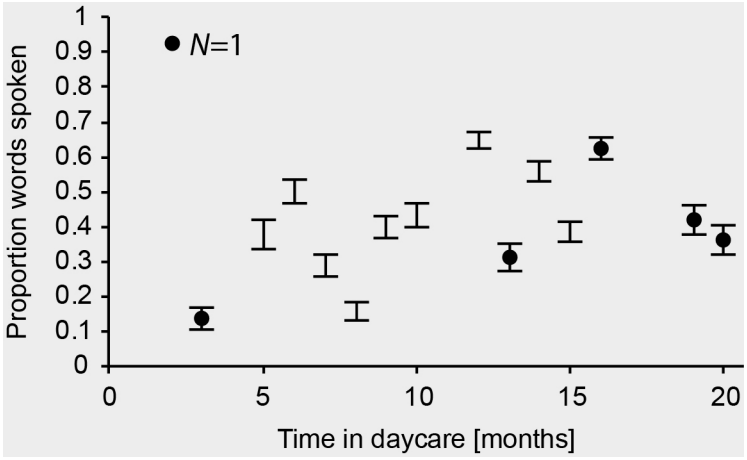


Figure 4. Proportions of spoken words according to the interaction of Gender and Group. Error bars denote 95% CIs for proportions.



841

842 *Figure 5.* Proportions of spoken words according to duration of daycare in months for the
843 children in the daycare group. Black dots mark CIs based on data of an individual child. Error
844 bars denote 95% CIs for proportions.

845

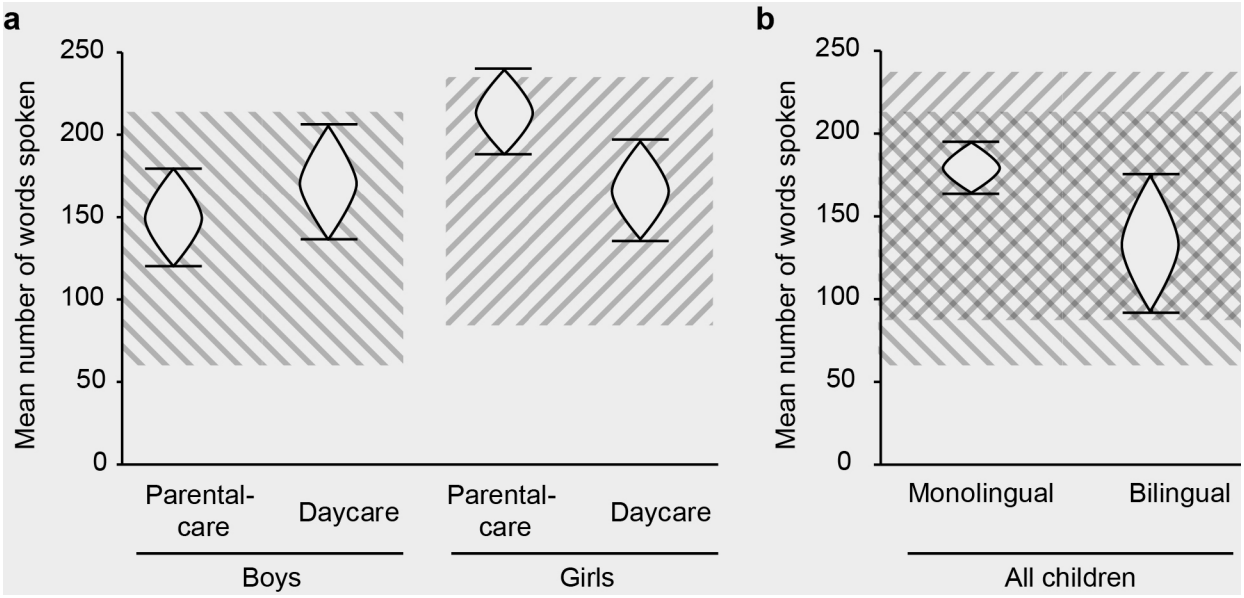


Figure 6. 95% CIs around mean number of words spoken by boys and girls in different care groups (a) as well as mono- and bilingual children (b). Cross-hatched areas mark ±1 *SD* around the mean number of words spoken by 24-month-old boys (lines from top-left to bottom-right) and girls (lines from bottom-left to top-right) in the norm sample of the ELAN manual (Bockmann & Kiese-Himmel, 2006).