

III: ANALYSES AND RESULTS FOR STUDY 1: ESTIMATING THE EFFECT OF LINGUISTIC DISTANCE ON VOCABULARY DEVELOPMENT

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To estimate the impact of linguistic distance on vocabulary development, which was the aim of Study 1, we needed to account for the effects of all situational factors that were known or suspected to shape bilingual development. This was achieved through a two-step analyses of the data from the 372 children whose Additional Language was 1 of our 13 target languages.

PLAN OF ANALYSES

In the first step, analyses were conducted on variables already established within the literature as strong predictors of vocabulary size (relative amount of exposure to each language in child-directed speech and overheard speech, gender, and SES). Analyses were conducted initially in ANCOVAs (to include

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continuous variables such as LEQ) and then subjected to confirmation in linear mixed models, with variables entered as fixed effects predictors only if they reached significance in the ANCOVAs.

In the second step, analyses were then conducted on less well-established variables (factors relative to source, properties and status, and measures of linguistic distance), in models containing verified predictors from the initial stage. Again, ANCOVAs were followed by linear mixed models with the same logic as in the first step.

The reasons behind this two-step process extend beyond the aims of Study 1, as explained below. The effects from the ANCOVAs would hold for a population with the same breakdown of language communities as those in our sample (e.g., which was 17.4% German, 12.8% French, etc.). The linear mixed models do not make that assumption and are thus strongly preferred if conclusions are to be generalized to all bilinguals. The purpose of the linear mixed models was indeed to provide the best possible test for the importance of candidate predictor variables for bilinguals generally, not merely those whose Additional Language was 1 of those 13 used in this monograph (and therefore preparing for Study 3). For this it was imperative that Language Community be modeled as a random, not a fixed effect, as the ANCOVAs would do.

In contrast, the value of the ANCOVAs is that they allow a straightforward test of the significance of simultaneously entered predictor variables, something that is problematic with linear mixed models due to a lack of consensus on how to compute the degrees of freedom for each predictor (Baayen, Davidson, & Bates, 2008). Our procedure was thus to perform a preliminary selection of significant predictors from ANCOVAs, subject to confirmation in linear mixed models, before finally being included in predictive models.

Following steps 1 and 2, predictive linear mixed models of expressive and receptive vocabulary for the UKBTAT tool (Study 2) were calculated with predictors retained only if their effect size in the ANCOVAs was larger than $\eta^2 = .02$ (Cohen, 1988), which is considered a threshold for small effects in ANOVAs and multiple regressions. These final models do not include measures of linguistic distance, since we aimed at developing norms that could be applied to any bilingual children learning British English, and measures of linguistic distance would not be available for Additional Languages that are not among our 13 target Additional Languages. Predictive models for the UKBTAT (Study 2) and the test of their generalization beyond the 13 target Additional Languages (Study 3) are presented in Chapter IV.

PREDICTOR VARIABLES

Step 1 predictors were language exposure scores (LEQ and Overheard speech), Gender, and SES. Language Community (which Additional

Language is spoken by the child) was included as a 13-level dummy variable simply to control for its effects. Step 2 predictors were the mode of exposure variables, and three Linguistic Distance variables. Mode of exposure variables belonged to three categories: *source* of each language (whether two parents are native Additional Language speakers or only one, total number of English speakers, total number of Additional Language speakers, number of siblings, time spent in English speaking daycare, time spent in Additional Language speaking daycare), *properties of the input* (degree of language use consistency in parents' speech, proportion of native English, proportion of native Additional Language), and *status of the Additional Language* (Welsh group vs. all other Additional Languages). Linguistic Distance variables were phonological overlap, word order typology, and morphological complexity.

Test language, or TestLang (English/Additional Language), was included as a repeated measures factor to examine the differential impact of predictors on English and Additional Language. See Table 1 for a summary of these variables.

VOCABULARY MEASURES

Dependent variables were CDI counts of receptive and expressive vocabulary in English and the Additional Language. We conducted analyses on two different versions of the CDIs. Our starting point was a 30 word CDI made up of those 30 words present in the Oxford Short Form CDI and all 13 Additional Language CDIs (see Table A5.1 in Appendix 5). This 30-word CDI had the advantage of holding items constant across a child's two test languages, thus controlling, among other things, for word frequency (although frequencies between translation equivalents differed, correlations were in the order of .8 over the 13 English-Additional Language pairings). The disadvantage of this approach is that, of the words common across all CDIs, a disproportionate number were high-frequency words. This results in a ceiling effect with, for example, over a third of children scoring 100% on English comprehension. Our second CDI used the full 100 words of the Oxford Short Form and the full Additional Language CDI re-represented as a percentage, to accommodate the fact that the standardized CDIs varied considerably in length for each language. While these data suffer from no ceiling effects and maximize the sampling of vocabulary, they are the least satisfactory in that there is no control of word frequency between all Additional Language CDIs, that is, obtaining a 40% score in the German CDI is not necessarily equivalent to a 40% in the Portuguese CDI. The main analyses reported here were performed on the 30-word CDI, with a specific section added for the data from the full CDIs. Given that the results were essentially similar when using the 30-word CDI or the full CDIs, please note

that the final equations in the UKBTAT (Chapter IV) are calculated from the 100 words of the Oxford Short Form for English (for increasing representativeness of the model's coefficients), and the 30 words for Additional Languages when relevant.

DESCRIPTIVE STATISTICS

Predictors

Tables 2–6 presented summary data of all predictor variables broken down by Language Community. Because of the strong associations between Language Community and predictor variables, it was important to use models that included Language Community to avoid attributing to predictor variables the explanatory power that was actually simply due to variability over language communities.

Vocabulary Measures

All data for vocabulary measures in English (for the full cohort) are reported in Table 7, and in Table 8 for each Additional Language (for the 372 target Additional Languages learners only). On the Oxford Short Form CDI, children understood on average 67.9 words and produced 41.2 words (variables CDI100Comp and CDI100Prod). On the Additional Language CDIs, which varied in length, children overall understood 54.9% of Additional Language words and produced 24.2% (PropALcomp and PropALprod). When restricting the analysis to the 30 words common to all CDIs, children understood on average 24.4 English words and produced 17.0 (variables CDI30comp and CDI30prod). For the target Additional Language, children understood on average 21.7 words and produced 11.2 (ALCDI30-Comp and ALCDI30Prod), which was significantly less than in English (comprehension: paired $t(371) = 6.25, p < .0001$; production $t(371) = 11.51, p < .0001$). As noted before, all main analyses provided below were run on the 30-word CDIs, with analyses on the full form CDIs provided in a specific section.

Of interest is the comparison of the bilingual scores to monolinguals. Based on the Oxford CDI database for 125 monolingual children aged 23.0–25.0, 24-month-olds understand 73.6% of the 416-word CDI ($SD = 16.9$) and produce 48.3% ($SD = 25.8$). To compare these scores to those of the Oxford Short Form CDI, we applied a correction ratio computed from the comparison between the long and short CDI described in the “Measuring vocabulary” section (see Methods). A score in the long CDI divided by .90 provides an equivalent score on the short CDI. That means that the

TABLE 7
ENGLISH VOCABULARY MEASURES FOR EACH ADDITIONAL LANGUAGE GROUP

	Oxford Short Form CDI				30 Words Common to All CDIs			
	Proportion of Words Understood		Proportion of Words Produced		Number of Words Understood		Number of Words Produced	
	CDI100Comp		CDI100Prod		CDI30comp		CDI30prod	
	Mean	<i>SD</i>	Mean	<i>SD</i>	Mean	<i>SD</i>	Mean	<i>SD</i>
Bengali	65.1	28.7	42.5	28.2	22.4	8.1	16.6	8.2
Cantonese Chinese	71.5	19.1	57.0	23.4	26.4	4.2	22.4	6.7
Dutch	76.9	16.1	44.7	18.5	27.2	3.9	18.7	7.1
French	76.9	19.5	45.0	24.3	26.9	4.2	19.0	8.1
German	68.3	23.8	38.4	24.2	24.7	5.7	16.2	8.8
Greek	71.4	15.7	46.5	23.1	26.7	2.9	19.4	8.3
Hindi/Urdu	61.6	36.4	32.6	33.4	20.9	10.6	12.6	11.2
Italian	71.7	23.6	34.8	26.5	25.8	5.0	15.3	9.8
Mandarin Chinese	65.5	23.8	47.1	28.3	23.9	5.7	19.1	8.2
Polish	60.6	28.1	37.1	27.2	22.5	8.6	15.3	10.1
Portuguese	65.0	24.1	46.1	24.6	24.4	6.4	20.3	7.2
Spanish	62.3	26.3	36.0	22.4	23.6	7.3	16.1	8.7
Welsh	65.2	29.0	43.9	30.6	22.7	8.2	16.3	9.4
Other	66.5	24.6	42.9	26.2	24.2	7.3	17.7	9.5
Mean	67.9	25.0	41.2	26.0	24.4	6.7	17.0	9.0

Note. Details for nontarget Additional Language children are provided under the row label "Other." CDI100comp and CDI100prod: mean number of words, respectively, understood and produced on the Oxford Short Version CDI; CDI30comp and CDI30prod: mean number of words understood and produced out of the 30 words common to all CDIs (30-word CDI).

24-month-old monolinguals are estimated to understand 81.8% of words and produce 53.7% if assessed with the Oxford Short Form CDI. In contrast, the cohort of 430 bilinguals understood 67.9% of the Oxford Short Form CDI ($SD = 25.0$) and produced 41.2% ($SD = 26.0$), which is significantly less than the monolinguals (comprehension: $t(553) = 5.84$, $p = .0001$; production: $t(553) = 4.74$, $p = .0001$).

RESULTS

Step 1—Predictors Firmly Established in the Literature

We looked at four predictors: LEQ (proportion of English in child-directed speech), overheard speech (proportion of English spoken between parents), SES, and gender. Three indices (income, maternal education, and

TABLE 8
 ADDITIONAL LANGUAGE VOCABULARY MEASURES FOR EACH ADDITIONAL LANGUAGE GROUP

	Additional Language CDIs				30 Words Common to All CDIs				AL CDI length
	Proportion of Words Understood		Proportion of Words Produced		Number of Words Understood		Number of Words Produced		
	PropALComp		PropALProd		ALCDI30Comp		ALCDI30Prod		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Bengali	50.6	25.9	32.3	25.0	6.2	2.2	4.2	2.5	62
Cantonese Chinese	40.7	25.7	20.7	13.6	15.5	9.0	9.1	7.1	389
Dutch	60.9	21.3	31.9	16.6	24.1	7.1	16.4	6.9	442
French	59.8	21.4	25.2	21.2	24.4	5.3	12.4	9.0	414
German	57.6	22.8	22.8	18.3	25.5	4.7	14.1	8.2	600
Greek	44.7	22.1	15.1	12.6	21.8	6.2	10.1	6.6	654
Hindi/Urdu	17.5	13.3	7.0	6.7	6.2	5.9	1.9	1.8	444
Italian	64.6	25.4	24.7	23.7	24.5	7.2	11.0	9.9	413
Mandarin Chinese	52.6	21.4	30.9	14.9	20.4	6.3	12.8	4.9	411
Polish	63.0	25.2	22.5	20.8	22.5	7.4	8.5	7.6	381
Portuguese	59.2	27.7	37.1	23.7	11.3	4.7	6.2	4.4	91
Spanish	49.3	21.9	20.1	17.1	23.1	7.1	12.2	9.4	591
Welsh	50.4	24.3	26.5	22.4	19.5	7.6	9.9	8.1	430
Mean	54.9	24.3	24.2	20.3	21.7	8.0	11.2	8.5	459.9

Note. PropALComp and PropALProd: mean proportion of words respectively understood and produced in the Additional Language as measured against the corresponding CDI; ALCDI30comp and ALCDI30prod: mean number of words understood and produced out of the 30-word CDIs; AL CDI length: total number of words in each Additional Language CDI.

paternal education) were initially selected as potential predictors for SES, but due to high correlations between income and parental education, and because income had the widest observed range, the latter was selected. Results are very similar if parental education is used. Thus our step 1 ANCOVA consisted of the between-subjects predictors of LEQ, overheard speech, income, and gender, with the within-subjects predictor of TestLang (Additional Language/English). Language Community was included as a between-subjects factor, since we wished to ascertain in Study 3 (as aforementioned) the degree to which all other predictors are generalizable to bilingual 24-month-olds regardless of the particular Additional Language she or he is learning. Separate ANCOVAs were run for production and comprehension scores. All ANCOVAs used as dependent variables the 30-words CDIs (see Tables 9 and 10 for full results in comprehension and production, respectively).

TABLE 9

ANCOVA RESULTS FOR COMPREHENSION ON THE 30-WORD CDIs (ENGLISH: CDI30Comp; ADDITIONAL LANGUAGE: ALCDI30Comp), IN STEP 1 ANALYSES (PREDICTORS FIRMLY ESTABLISHED IN THE LITERATURE)

	Sum of Squares	<i>df</i>	<i>F</i>	<i>p</i>	η^2
With TestLang included					
TestLang	15.31	1,342	41.77	.000	.109
LEQ	.21	1,342	.21	.64	.001
Gender	1.39	1,342	1.39	.24	.004
Income	11.97	1,342	11.97	.001	.034
Overheard speech	10.56	1,342	10.56	.001	.030
Language community	86.52	12,342	7.21	.000	.202
TestLang*LEQ	27.51	1,342	75.07	.000	.180
TestLang*Gender	.019	1,342	.052	.820	.000
TestLang*Income	.259	1,342	.707	.401	.002
TestLang*Overheard speech	14.19	1,342	38.72	.000	.102
TestLang*Language community	48.83	12,342	11.10	.000	.280
On English scores only					
LEQ	16.30	1,342	21.46	.000	.059
Gender	.87	1,342	1.14	.286	.003
Income	4.35	1,342	5.73	.017	.016
Overheard speech	24.61	1,342	32.42	.000	.087
Language community	16.198	12,342	1.78	.050	.059
On Additional Language scores only					
LEQ	11.43	1,342	18.81	.000	.052
Gender	.54	1,342	.89	.34	.003
Income	7.87	1,342	12.95	.000	.036
Overheard speech	.13	1,342	.22	.64	.001
Language community	119.14	12,342	16.33	.000	.364

Note. TestLang = English versus Additional Language. All variables are z-scored. $N = 359$ as income data was not provided for 13 children out of 372.

For comprehension there was no main effect of LEQ, but an interaction of LEQ and TestLang ($F_{1,342} = 75.07$, $p < .001$, $\eta^2 = .18$). Analysis of the effect of LEQ on each test language separately revealed that it significantly reduced Additional Language scores ($F_{1,342} = 18.81$, $p < .001$, $\eta^2 = .05$) and increased English scores ($F_{1,343} = 21.46$, $p < .001$, $\eta^2 = .06$): the more child-directed English children heard, the more English they understood, and the less Additional Language they understood (see Figure 1). Overheard speech (the proportion of English vs. the Additional Language spoken between the parents when the child was present) significantly increased comprehension scores overall ($F_{1,342} = 10.55$, $p = .001$, $\eta^2 = .03$), and showed an interaction with TestLang ($F_{1,342} = 38.72$, $p < .001$, $\eta^2 = .10$). Breaking down the effect of Overheard speech for the two test languages, while no effect was seen for Additional Language ($F < 1$), a beneficial effect was seen for English

TABLE 10

ANCOVA RESULTS FOR PRODUCTION ON THE 30-WORD CDIs (ENGLISH: CDI30Prod; ADDITIONAL LANGUAGE: ALCDI30Prod), IN STEP 1 ANALYSES (PREDICTORS FIRMLY ESTABLISHED IN THE LITERATURE)

	Sum of Squares	<i>df</i>	<i>F</i>	<i>p</i>	η^2
With TestLang included					
TestLang	5.29	1,342	13.66	.000	.038
LEQ	.41	1,342	.32	.57	.001
Gender	26.82	1,342	21.00	.000	.058
Income	4.33	1,342	3.39	.066	.010
Overheard speech	1.19	1,342	.93	.34	.003
Language community	23.92	12,342	1.56	.101	.052
TestLang*LEQ	35.45	1,342	91.58	.000	.211
TestLang*Gender	.054	1,342	.14	.71	.000
TestLang*Income	.212	1,342	.55	.46	.002
TestLang*Overheard speech	13.19	1,342	34.08	.000	.091
TestLang*Language community	22.96	12,342	4.94	.000	.148
On English scores only					
LEQ	21.75	1,342	25.94	.000	.071
Gender	14.64	1,342	17.47	.000	.049
Income	1.31	1,342	1.57	.21	.005
Overheard speech	11.15	1,342	13.30	.000	.037
Language community	7.32	12,342	.73	.72	.025
On Additional Language scores only					
LEQ	14.11	1,342	17.09	.000	.048
Gender	12.23	1,342	14.81	.000	.042
Income	3.23	1,342	3.91	.049	.011
Overheard speech	3.29	1,342	3.91	.049	.011
Language community	39.56	12,342	3.99	.000	.123

Note. TestLang = English versus Additional Language. All variables are z-scored. $N = 359$ as income data was not provided for 13 children out of 372.

($F_{1,342} = 32.42$, $p < .001$, $\eta^2 = .09$). The more English spoken between the parents, the more beneficial effect on English comprehension (see Figure 2). A main effect of Income was found ($F_{1,342} = 11.97$, $p = .001$, $\eta^2 = .03$) and no interaction with TestLang. There was no main effect of Gender ($F_{1,342} = 1.39$, $p = .24$) or interaction with TestLang ($F_{1,342} = .05$, $p = .82$).

For production no main effect of LEQ was observed but again an interaction with TestLang was seen ($F_{1,342} = 91.58$, $p < .001$, $\eta^2 = .21$). As in comprehension, individual analyses on each of the test languages revealed a negative effect of LEQ on Additional Language scores ($F_{1,342} = 17.09$, $p < .001$, $\eta^2 = .05$) and a positive effect of LEQ on English scores ($F_{1,342} = 25.94$, $p < .001$, $\eta^2 = .07$) (see Figure 1). Overheard speech showed no main effect but did show an interaction with TestLang ($F_{1,342} = 34.08$, $p < .001$, $\eta^2 = .09$). Breaking down the effect for the two test languages showed a significant detrimental effect on Additional Language ($F_{1,342} = 3.91$,

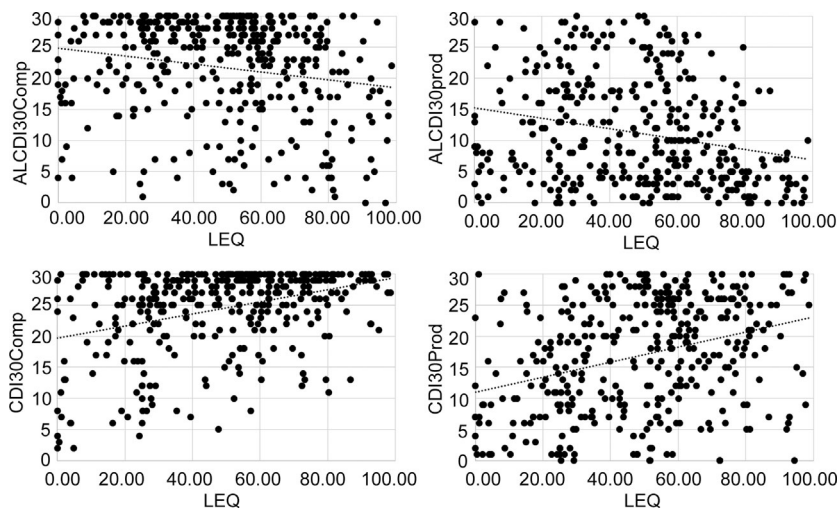


FIGURE 1.—Vocabulary scores measured on the 30-words CDI as a function of the amount of exposure to English in child directed speech as measured by the LEQ (%). Top left: Additional Language comprehension; top right: Additional Language production; bottom left: English comprehension; bottom right: English production.

$p = .049$, $\eta^2 = .01$) and a beneficial effect on English ($F_{1,342} = 143.30$, $p < .001$, $\eta^2 = .04$) (see Figure 2).

Income did not have a significant effect ($F_{1,342} = 3.39$, $p = .07$) and there was no interaction with TestLang ($F_{1,342} = .55$, $p = .46$). There was a main effect of Gender ($F_{1,342} = 21.00$, $p < .001$, $\eta^2 = .06$), with girls outperforming boys and no interaction with TestLang ($F_{1,342} = .14$, $p < .71$) (see Figure 3).

Linear mixed models were then carried out with fixed effects only for those predictors that reached significance in the aforementioned ANCOVAs, with random slopes and intercept for Language Community and random intercepts for participants. Separate models were conducted for each fixed effect variable, with significance assessed by comparing each model against a null in which the fixed effect was absent. Linear mixed models were calculated using the lme4 package (Bates, Maechler, Bolker, & Walker, 2014) in the R environment (R Development Core Team, 2006, version 0.99.896). The coefficients for each model are given in Table 11 (comprehension) and Table 12 (production). Note that the effect that is tested in these comparisons is the combined main effect and interaction with TestLang if one was indicated by the ANCOVAs.

For comprehension there was a significant effect of LEQ ($\chi^2(2) = 18.02$, $p < .001$) and Overheard speech ($\chi^2(2) = 18.62$, $p < .001$) but no effect of Income ($\chi^2(1) = 1.60$, $p = .21$). For production there was a significant effect of LEQ ($\chi^2(2) = 18.75$, $p < .001$), Overheard speech ($\chi^2(2) = 23.59$,

English vocabulary as a function of Overheard speech

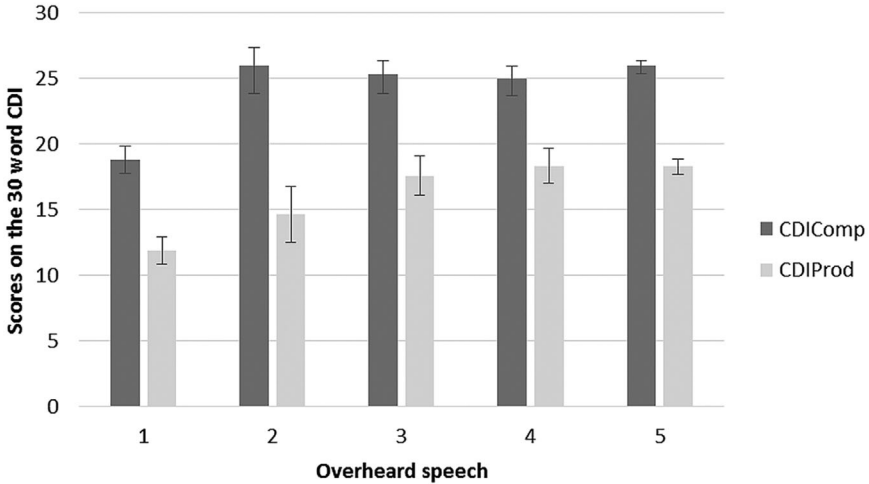


FIGURE 2.—English vocabulary scores in comprehension and production measured on the 30-words CDI as a function of the proportion of English spoken between parents (Overheard speech). Overheard speech ranges from 1 (only Additional Language) to 5 (only English).

Effect of gender on vocabulary size

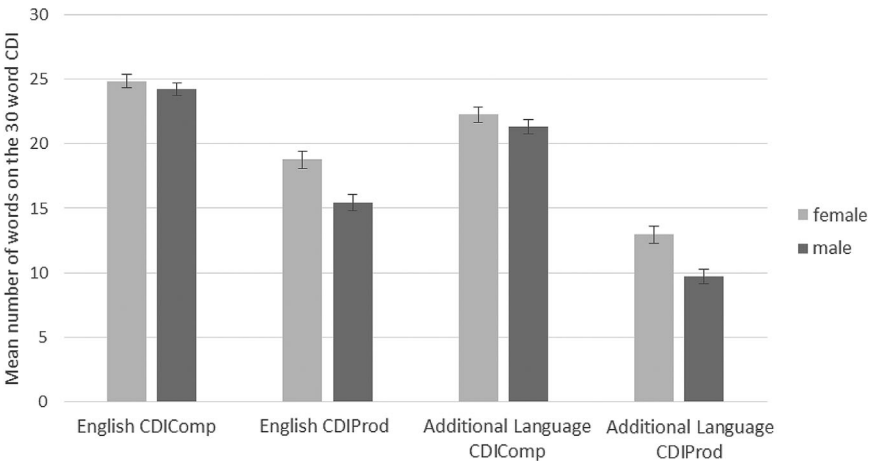


FIGURE 3.—English and Additional Language vocabulary in comprehension (CDIComp) and production (CDIProd) on the 30-words CDI as a function of child's gender.

TABLE 11

COEFFICIENT ESTIMATES FROM THE LINEAR MIXED MODELS USED IN STEP 1 ANALYSES AFTER THE ANCOVAs, TO ESTIMATE THE ROBUSTNESS OF EACH PREDICTOR INDIVIDUALLY, IN COMPREHENSION, ON THE 30-WORD CDIs (ENGLISH: CDI30Comp; ADDITIONAL LANGUAGE: ALCDI30Comp)

Fixed Effect	Coef.	SE	<i>t</i>	χ^2	<i>p</i>
LEQ					
Intercept	-0.63	0.40	-1.59		
LEQ	-0.64	0.11	-5.79		
TestLang	0.30	0.18	1.65		
LEQ:TestLang	0.47	0.07	6.36	18.02	.000
Overheard speech					
Intercept	-0.79	0.48	-1.66		
Overheard speech	-0.56	0.12	-4.78		
TestLang	0.43	0.24	1.76		
Overheard speech:TestLang	0.47	0.08	6.04	18.62	.000
Income					
Intercept	-0.68	0.42	-1.60		
Income	0.09	0.06	1.48		
TestLang	0.33	0.20	1.65	1.60	.21

Note. For each variable which survived the ANCOVAs, such as LEQ, tests of significance (χ^2) to compare the full model and its null are provided in the last two columns. TestLang = English versus Additional Language. All variables are *z*-scored. *N* = 372 apart from the last model in which *N* = 359 as income data was not provided for 13 children out of 372.

TABLE 12

COEFFICIENT ESTIMATES FROM THE LINEAR MIXED MODELS USED IN STEP 1 ANALYSES AFTER THE ANCOVAs, TO ESTIMATE THE ROBUSTNESS OF EACH PREDICTOR INDIVIDUALLY, IN PRODUCTION, ON THE 30-WORD CDIs (ENGLISH: CDI30Prod; ADDITIONAL LANGUAGE: ALCDI30Prod)

Fixed Effect	Coef.	SE	<i>t</i>	χ^2	<i>p</i>
LEQ					
Intercept	-0.27	0.22	-1.24		
LEQ	-0.73	0.10	-7.21		
TestLang	0.13	0.11	1.22		
LEQ:TestLang	0.52	0.07	7.64	18.75	.000
Overheard speech					
Intercept	-0.39	0.26	-1.49		
Overheard speech	-0.55	0.11	-5.01		
TestLang	0.22	0.15	1.49		
Overheard speech:TestLang	0.42	0.06	7.25	23.50	.000
Gender					
Intercept	-0.28	0.22	-1.24		
Gender	-0.20	0.04	-4.75		
TestLang	0.14	0.12	1.20	13.26	.000

Note. For each variable which survived the ANCOVAs, such as LEQ, tests of significance (χ^2) to compare the full model and its null are provided in the last two columns. TestLang = English versus Additional Language. *N* = 372. All variables were *z*-scored.

TABLE 13

COEFFICIENT ESTIMATES FROM THE LINEAR MIXED MODELS USED IN STEP 1 ANALYSES AFTER THE ANCOVAs, TO ESTIMATE THE ROBUSTNESS OF EACH PREDICTOR WHEN INCREMENTED ONTO MODELS CONTAINING THE OTHER ONES

	Coef.	SE	<i>t</i>	χ^2	<i>p</i>
Comprehension					
Full model					
Intercept	-0.67	0.39	-1.69		
LEQ	-0.58	0.11	-5.40		
TestLang	0.40	0.19	2.10		
Overheard speech	-0.31	0.08	-3.67		
LEQ:TestLang	0.37	0.07	5.28		
TestLang:Overheard speech	0.34	0.05	6.33		
Comparison full/null model for variable					
LEQ				13.60	.001
Overheard speech				16.21	.000
Production					
Full model					
Intercept	-0.24	0.18	-1.39		
LEQ	-0.60	0.11	-5.60		
TestLang	0.16	0.09	1.69		
Overheard speech	-0.32	0.10	-3.24		
Gender	-0.20	0.05	-4.38		
LEQ:TestLang	0.41	0.08	4.85		
TestLang:Overheard speech	0.27	0.07	4.11		
Comparison full/null model for variable					
LEQ				12.20	.002
Overheard speech				10.93	.006
Gender				10.28	.001

Note. Dependent variables are the scores on the 30-word CDIs in comprehension (English: CDI30Comp; Additional Language: ALCDI30Comp) and production (English: CDI30Prod; Additional Language: ALCDI30Prod). For variables which survived the ANCOVA stages and the initial linear mixed models with single predictors (Tables 9–12), the coefficients for the full models are presented. Then for each variable of interest, such as LEQ, tests of significance (χ^2) to compare the full model and its null are provided in the last two columns. TestLang = English versus Additional Language. $N = 372$. All variables were *z*-scored.

$p < .001$), and Gender ($\chi^2(1) = 13.26$, $p < .001$). When these analyses were conducted again with each significant fixed effect entered into a model already containing the other significant fixed effects (Table 13), the last entered fixed effect retained its significance ($p < .006$) in each case. Because we consider the linear mixed models to be the more appropriate significance test for a model that generalizes to all bilinguals (Study 3), Income was discarded as a predictor for subsequent analyses. The remaining predictors at the end of Step 1 were the relative amount of exposure to English in child-directed speech (LEQ), the proportion of English in parental overheard speech (Overheard speech), and Gender. This first step allowed us to confirm

the robustness of predictors from the literature for the building of a model of the child's lexicon (Study 2), based on data from the 13 target Additional Languages learners.

Step 2—Secondary Predictors

Secondary variables were then added to ANCOVAs containing those predictors shown to be significant in the Step 1 analysis above (LEQ, Overheard speech, and Gender), with the 30 words common to all CDIs as dependent variables. These predictors were all the mode of exposure variables, and the three Linguistic Distance variables.

Mode of exposure variables were assessed by adding them individually to ANCOVAs containing LEQ, Overheard speech and, in the case of production, Gender. Societal status (variable Status), degree of language use consistency in parents' input (variable Consistency), presence of siblings (variable Siblings), and number of parental native Additional Language speakers (one or two; variable FamLang) were added to a model containing TestLang as a within-subjects factor. Models with only Additional Language or English test scores omitted the factor of TestLang but included factors describing the native input of test language (variables PropEngN and PropALN), the number of sources of test language (SourcesEng and SourcesAL), and the amount of day care provided in the test language (EngDaycare and ALDaycare).

Only two variables achieved significance: Consistency and PropEngN (see Table 14). Consistency interacted significantly with TestLang in determining production scores ($F_{1,355} = 3.94, p = .047, \eta^2 = .01$), due to English vocabulary being boosted by a decreasing consistency in parents' use of the two languages ($F_{1,355} = 6.07, p = .014, \eta^2 = .017$): the more parents used a mix of English and the Additional Language, and the more English vocabulary was produced. The proportion of parental native English spoken (PropEngN) significantly improved English production scores ($F_{1,296} = 4.12, p = .043, \eta^2 = .01$) (Table 14).

The effect of Consistency on English production scores was confirmed with a linear mixed model ($\chi^2(1) = 5.79, p = .016$), however, owing to the very small effect size, this variable was not included in the UKBTAT predictive models. The effect of proportion of native English spoken on English production scores was not supported by a linear mixed model ($\chi^2(1) < 1$), and was not retained in the UKBTAT equations.

Finally, the three Linguistic Distance variables were assessed, phonological overlap, word order typology, and morphological complexity. Because these showed a perfect to very high association with Language Community, these factors could not be added to ANCOVAs and were assessed in linear mixed models only (see Tables 15–17). These revealed a significant effect of

TABLE 14

ANCOVA RESULTS FOR STEP 2 ANALYSES (SURVIVING PREDICTORS FROM STEP 1 PLUS LESS WELL-ESTABLISHED PREDICTORS), RESTRICTED TO THOSE PREDICTORS PROVIDING SIGNIFICANT EFFECTS

	Sum of squares	<i>df</i>	<i>F</i>	<i>p</i>	η^2
Effect of mixing on production with TestLang included					
TestLang*LEQ	29.92	1,355	79.16	.000	.182
TestLang*Gender	.013	1,355	.035	.85	.000
TestLang*Overheard speech	14.35	1,355	37.95	.000	.097
TestLang*Consistency	1.49	1,355	3.94	.048	.011
TestLang*Language community	21.65	12,355	4.77	.000	.139
Effect of mixing on English production					
LEQ	17.21	1,355	20.93	.000	.056
Gender	12.63	1,355	15.36	.000	.041
Overheard speech	14.40	1,355	17.52	.000	.047
Consistency	4.99	1,355	6.07	.014	.017
Language community	8.48	12,355	.86	.59	.028
Effect of the proportion of native English on English production					
LEQ	20.69	1,296	24.20	.000	.076
Gender	7.20	1,296	8.42	.004	.028
Overheard speech	9.67	1,296	11.31	.001	.037
EngPropN	3.53	1,296	4.12	.043	.014
Language community	8.39	12,296	.82	.63	.032

Note. The dependent variables are scores in production on the 30-word CDIs (English: CDI30Prod; Additional Language: ALCDI30Prod). TestLang = English versus Additional Language. All variables were *z*-scored. The effect of Consistency (degree of language use consistency in parental speech, see Appendix 2) is calculated with $N=372$. The effect of the proportion of native versus nonnative English in parental speech (PropEngN) is calculated for $N=313$ due to 59 children for whom this variable could not be computed (see Appendix 2).

Phonological Overlap on Additional Language production ($\chi^2(1) = 4.61$, $p = .032$), a significant effect of Word Order typology on Additional Language comprehension ($\chi^2(1) = 6.02$, $p = .014$), and a significant effect of Morphological Complexity on Additional Language comprehension ($\chi^2(1) = 4.80$, $p = .028$). In all three cases, an advantage was found for children learning an Additional Language close to English. No effects on English were seen.

In summary, all variables but two (Consistency and PropEngN) from Step 2 analyses were excluded at the ANCOVA stage, due to lack of significance. Consistency did have a significant effect in the subsequent linear mixed models but its effect size was too small to warrant integration in the UKBTAT predictive models (Study 2, next chapter). PropEngN (proportion of English that is native) failed to reach significance in the linear mixed models, and therefore will not be included in the UKBTAT models. All measures of Linguistic Distance were found to be significant in

TABLE 15

COEFFICIENT ESTIMATES FROM THE LINEAR MIXED MODELS USED IN STEP 2 ANALYSES AFTER THE ANCOVAs, TO ESTIMATE THE EFFECT OF PHONOLOGICAL OVERLAP ON VOCABULARY IN EACH LANGUAGE, WHEN INCREMENTED ONTO MODELS CONTAINING THE PREDICTORS RETAINED FROM STEP 1 ANALYSES

	Coef.	SE	<i>t</i>	χ^2	<i>p</i>
English comprehension					
Intercept	0.04	0.07	0.54		
Phonological overlap	-0.02	0.06	-0.37		
LEQ	0.22	0.07	3.02		
Overheard speech	0.31	0.06	5.47	0.11	.74
Additional Language comprehension					
Intercept	-0.16	0.23	-0.70		
Phonological overlap	0.37	0.19	1.90		
LEQ	-0.17	0.05	-3.38	2.41	.12
English production					
Intercept	0.005	0.05	0.11		
Phonological overlap	-0.04	0.05	-0.73		
LEQ	0.26	0.08	3.22		
Overheard speech	0.21	0.06	3.68		
Gender	-0.20	0.05	-4.19	0.53	.47
Additional Language production					
Intercept	-0.03	0.10	-0.30		
Phonological overlap	0.24	0.09	2.61		
LEQ	-0.22	0.05	-4.05		
Gender	-0.18	0.06	-3.31	4.61	.032

Note. Dependent variables are scores on the 30-word CDIs in comprehension (English: CDI30Comp; Additional Language: ALCDI30Comp) and production (English: CDI30Prod; Additional Language: ALCDI30Prod). Tests of significance to compare each full model to its null (without the fixed effect of Phonological Overlap) are provided in the last two columns. $N=372$. All variables were z-scored.

the linear mixed models, fulfilling the predictions of Study 1. It must be kept in mind, however, that all results obtained at Step 2 should be taken in the context of multiple comparisons and viewed as subject to confirmation in future studies.

Metrics of linguistic distance will not be included in the UKBTAT models (Study 2) because our aim was to build a predictive model for any bilingual child learning British English (Study 3), and measures of linguistic distance will not be available for any Additional Language different from our 13 target languages.

Comparison With Full CDI

The effects found in the Step 1 analysis were checked in the full CDI data (the proportion of words in the 100-word Oxford Short Form CDI and in the

TABLE 16

COEFFICIENT ESTIMATES FROM THE LINEAR MIXED MODELS USED IN STEP 2 ANALYSES AFTER THE ANCOVAs, TO ESTIMATE THE EFFECT OF WORD ORDER TYPOLOGY ON VOCABULARY IN EACH LANGUAGE, WHEN INCREMENTED ONTO MODELS CONTAINING THE PREDICTORS RETAINED FROM STEP 1 ANALYSES

	Coef.	SE	<i>t</i>	χ^2	<i>p</i>
English comprehension					
Intercept	0.04	0.07	0.62		
Word order	-0.09	0.05	-1.62		
LEQ	0.22	0.07	2.91		
Overheard speech	0.30	0.052	5.87	2.29	.13
Additional Language comprehension					
Intercept	-0.25	0.18	-1.42		
Word order	-0.39	0.14	-2.79		
LEQ	-0.17	0.06	-3.02	6.02	.014
English production					
Intercept	0.005	0.05	0.10		
Word order	-0.04	0.05	-0.92		
LEQ	0.26	0.08	3.34		
Overheard speech	0.21	0.06	3.62		
Gender	-0.20	0.05	-4.30	0.84	.36
Additional Language production					
Intercept	-0.10	0.11	-0.92		
Word order	-0.12	0.09	-1.37		
LEQ	-0.21	0.06	-3.76		
Gender	-0.19	0.049	-3.91	1.50	.22

Note. Dependent variables are scores on the 30-word CDIs in comprehension (English: CDI30Comp; Additional Language: ALCDI30Comp) and production (English: CDI30Prod; Additional Language: ALCDI30Prod). Tests of significance to compare each full model to its null (without the fixed effect of Word Order) are provided in the last two columns. $N=372$. All variables were z-scored.

original Additional Language CDIs). The pattern of significance was identical with effect sizes highly comparable. In particular, linear mixed models once again showed no effect of Income on comprehension ($\chi^2(1) = 1.36, p = .24$).

On a final note, in the analyses provided in this monograph, we have deliberately ignored item-level analyses as they are beyond our current scope (but see Table A5.2 in Appendix 5 for a breakdown of comprehension and production of each English word in the 30-word CDI, as a function of exposure). However, further analyses at this level would provide a privileged insight of the internal organization of the bilingual lexicon, complementing pioneering studies regarding the processes by which new words are added to the lexicon in monolinguals (e.g., Hills, Maouene, Maouene, Sheya, & Smith, 2009) or bilinguals (Bilson, Yoshida, Tran, Woods, & Hills, 2015). By comparison, where Bilson et al. (2015) collected data in 181 children spanning the age of 6 months to 78 months from eight different English-Additional Language pairs, using a version of the MCDI Toddler form designed for children aged 16–30 months of age (Fenson et al., 2007), our

TABLE 17

COEFFICIENT ESTIMATES FROM THE LINEAR MIXED MODELS USED IN STEP 2 ANALYSES AFTER THE ANCOVAs, TO ESTIMATE THE EFFECT OF MORPHOLOGICAL COMPLEXITY (Morph) ON VOCABULARY IN EACH LANGUAGE, WHEN INCREMENTED ONTO MODELS CONTAINING THE PREDICTORS RETAINED FROM STEP 1 ANALYSES

	Coef.	SE	<i>t</i>	χ^2	<i>p</i>
English comprehension					
Intercept	0.04	0.07	0.57		
Morph	-0.07	0.05	-1.36		
LEQ	0.22	0.07	3.11		
Overheard speech	0.30	0.05	5.93	1.77	.18
Additional Language comprehension					
Intercept	-0.32	0.19	-1.70		
Morph	-0.28	0.11	-2.49		
LEQ	-0.19	0.06	-3.27	4.80	.028
English production					
Intercept	0.005	0.05	.10		
Morph	-0.05	0.05	-1.07		
LEQ	0.26	0.08	3.40		
Overheard speech	0.20	0.06	3.55		
Gender	-0.20	0.05	-4.21	1.13	.29
Additional Language production					
Intercept	-0.10	0.09	-1.05		
Morph	-0.14	0.06	-2.17		
LEQ	-0.22	0.06	-3.96		
Gender	-0.17	0.05	-3.46	3.80	.051

Note. Dependent variables are scores on the 30-word CDIs in comprehension (English: CDI30Comp; Additional Language: ALCDI30Comp) and production (English: CDI30Prod; Additional Language: ALCDI30Prod). Tests of significance to compare each full model to its null (without the fixed effect of Morph) are provided in the last two columns. $N = 372$. All variables were *z*-scored.

dataset includes data for both English and Additional Language (when available) from 430 24-month-olds, collected using age-appropriate tools. One application of these data now currently being conducted is to examine whether phonological overlap modulates the 2-year-old bilingual lexicon in terms of associative relationships and frequency for translation equivalents.

KEY FINDINGS

The aim of Study 1 was to establish whether measures of linguistic distance could predict vocabulary size at age 2 in bilingual toddlers. To achieve this, we first showed that vocabulary size was modulated by a set of robust factors from the literature: relative amount of exposure to English versus the Additional Language (English and Additional Language

comprehension and production), proportion of English in overheard speech (English comprehension and production) and gender (English and Additional Language production). Two other, less-established predictors emerged: first, English production was boosted when each parent used a mix of languages as compared to using one language only—but due to its very small effect size this variable will not be included in the subsequent UKBTAT equations. Second, the proportion of native English spoken by parents significantly improved English production scores—but this effect did not survive in linear mixed models and therefore will not be included in the UKBTAT. No other variables reached significance, in particular not SES.

Importantly, we found that the three measures of linguistic distance predicted vocabulary knowledge in 2-year-olds learning British English and 1 of 13 target Additional Languages, above and beyond variance due to Language Community: phonological overlap, SVO order typology, and morphological complexity. Specifically, we found that children learning a language phonologically close to English had a larger production vocabulary in their Additional Language; similarly, those learning typologically or morphologically close languages to English had a larger Additional Language comprehension vocabulary.