# Vocabulary of 2-year-olds learing English and an additional language

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# Vocabulary of 2-Year-Olds Learning English and an Additional Language: Norms and Effects of Linguistic Distance



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## Abstract

Typically-developing bilingual children usually underperform relative to monolingual norms when assessed in one language only. We measured vocabulary with Communicative Development Inventories for 372 24-month-old toddlers learning British English and one Additional Language out of a diverse set of 13 (Bengali, Cantonese, Dutch, French, German, Greek, Hindi-Urdu, Italian, Mandarin, Polish, Portuguese, Spanish and Welsh). We furthered theoretical understanding of bilingual development by showing, for the first time, that linguistic distance between the child's two languages predicts vocabulary outcome, with phonological overlap related to expressive vocabulary, and word order typology and morphological complexity related to receptive vocabulary, in the Additional Language. Our study also has crucial clinical implications: we have developed the first bilingual norms for expressive and receptive vocabulary for 24-month-olds learning British English and an Additional Language. These norms were derived from factors identified as uniquely predicting CDI vocabulary measures: the relative amount of English versus the Additional Language in child-directed input and parental overheard speech, and infant gender. The resulting UKBTAT tool was able to accurately predict the English vocabulary of an additional group of 58 bilinguals learning an Additional Language outside our target range. This offers a pragmatic method for the assessment of children in the majority language when no tool exists in the Additional Language.

**Vocabulary of 2-Year-Olds Learning English and an Additional Language: Norms and Effects of Linguistic Distance**

## Chapter 1 – Introduction

The majority of the world's population grows up with two languages or more (Kohnert, 2010), including an increasing proportion of UK children (17.5% in primary schools; NALDIC, 2012). It is well documented that bilinguals generally command a smaller vocabulary in each language than monolinguals (e.g. Bialystok, Luk, Peets, & Yang, 2010; Hoff et al., 2012; Miękisz et al., 2016; Oller & Eilers, 2002; Perani et al., 2003; Portocarrero, Burright, & Donovick, 2007; Smithson, Paradis, & Nicoladis, 2014). This fact is critical for assessing children's language development because vocabulary size is a central measure of progress in both the oral and literate forms of language (Muter, Hulme, Snowling, & Stevenson, 2004). Indeed, vocabulary size correlates highly with grammatical development (Conboy & Thal, 2006; Thal, Bates, Goodman, & Jahn-Samilo, 1997), and is strongly predictive of later language impairment (Conti-Ramsden & Botting, 1999; Dale, Price, Bishop, & Plomin, 2003) and reading comprehension skills (Duff, Reen, Plunkett, & Nation, 2015), making it a reasonable proxy of language development achievements in young toddlers (see also Cattani et al., 2014).

Getting an accurate estimate of the "bilingual difference" in vocabulary size for each language is a prerequisite to adapting existing assessment tools for the evaluation of bilingual toddlers' language achievements. Furthermore, language disorders occur with similar prevalence in both the monolingual and bilingual populations (Kohnert, 2010), with all children having a 7-15% chance of experiencing delayed language acquisition due, for example, to pervasive developmental disorders such as autism (e.g. 2.6%, Kim et al., 2011), hearing impairment (e.g. 1% in Fortnum et al., 2001) or Developmental Language Disorder (e.g. 7%, Tomblin et al., 1997). Current language assessment methods are based upon expectations for monolingual learners, and take no account of comparative delays seen in typical bilingual lexical development (Gathercole, 2007) or grammar (Bedore & Peña, 2008; Bialystok, 2009; Kohnert, 2010). Thus, according to circumstances, bilinguals, who are in reality typically-developing, may be diagnosed with spurious acquisition problems or have genuine problems ignored (e.g., Crutchley, 2000; Salameh, Nettelbladt, Håkansson, & Gullberg, 2002, for evidence of under-referral in bilingual children). Moreover, whilst recommendations to practitioners are that both L1 and L2 language proficiency should be assessed (American Speech-Language-Hearing Association, 1999; Royal College of Speech and Language Therapists, 2007), this is in practice complicated by the diversity of language pairs (Cattani et al., 2014; Thordardottir, Rothenberg, Rivard, & Naves, 2006).

An approach advocated by Pearson, Fernandez and Oller (1993) for Spanish-English and Junker and Stockman (2002) for German-English bilinguals is to obtain for each child her total vocabulary in the two languages, either by counting all tokens (Total Vocabulary or TV; e.g. *dog* and its French equivalent *chien* would count as one entry each) or counting two known translation equivalents as one (Total Conceptual Vocabulary or TCV; e.g. *dog* and *chien* would count as one entry). Based on findings that bilingual children score similar to monolinguals when using their TV or TCV measures, it was proposed that bilingual norms might not be necessary, as long as vocabulary could be estimated in both languages. However, Thordardottir et al. (2006) reported that the use of TCV/TV measures was not appropriate for balanced bilinguals, that is, those hearing equal amounts of each language on a regular basis, or children whose language dominance is not clear. They attributed this to the large overlap in knowledge from their two languages, which would modulate the relationship between measures using one language (monolingual norms) or two languages (TV/TCV). In addition and most importantly, they found that the comparison of TCV/TV to monolingual norms was highly dependent on which monolingual group is used for comparison, as vocabulary growth can vary substantially between languages (Thordardottir, 2005), for example when presented with a particularly complex vowel system as in Danish (Bleses et al., 2008). Core, Hoff, Rumiche and Señor (2013) also found that between 22 and 30 months, TCV scores placed significantly more bilinguals below the 25th percentile on monolingual norms than single-language scores did for monolinguals (see also Gross, Buac, & Kaushanskaya, 2014).

Therefore, although measuring bilingual vocabulary with appropriate tools is a necessity, it appears to be an impractical task given the variety of factors that might shape lexical growth in these children, from the variation between language pairs to situational factors such as amount and mode of exposure (e.g. Hoff et al., 2012; Place & Hoff, 2011). The aim of this study is to provide a new functional approach to the evaluation of vocabulary knowledge in bilingual children, addressing the diversity of bilingual children's situations, in particular, variation in the linguistic distance between each bilingual child's two languages. To our knowledge, this is the first time that data were collected from a large cohort of bilingual children learning a variety of language pairs (British English plus one of 13 languages), in an attempt to capture empirically the effect of language community and linguistic distance on other factors known to modulate vocabulary growth in bilingual children. In addition, by focusing on children who share one language (here, British English), we avoid having to rely on different standardised tools that may vary dramatically across languages (Thordardottir, 2005). As we will argue, the results are theoretically and clinically relevant: not only do we show that linguistic distance shapes some aspects of vocabulary growth at age 2, but we also provide a practical solution to the universal problem of assessing bilingual children's language achievements. Whilst the resulting norms of vocabulary growth are specific to children learning British English as one of their languages, our rationale and methods are, we believe, generalisable to any new population of bilingual toddlers.

**Assessing Language Development: The Case of the UK**

In the historical context of the British Empire and more recent European Union expansion, the UK bilingual population is characterised by a great diversity of language backgrounds, with no predominant group such as Spanish-English in the US (with the exception of Welsh in North Wales). As such, it can be taken as a representative case study for the widespread situation where the Early Years Practitioner has no easy access to an appropriate standardised monolingual assessment tool, let alone a bilingual tool. In what follows we will review briefly the current practices of screening and assessment of bilingual children in the UK, as carried out by Early Years Professionals, Health Visitors (i.e., qualified and registered nurses or midwives with additional training and qualifications to act as specialist community public health nurses), or Speech and Language Therapists (SLTs).

Recently, the Dynamic Assessment of Preschoolers' Proficiency in Learning English (DAPPLE) was developed in the UK to respond to the clinical need to distinguish between a disorder and the bilingual difference, using a mixed group of bilinguals, that is, children learning English and a variety of Additional Languages (Hasson, Camilleri, Jones, Smith, & Dodd, 2013). This assessment examines the children's ability to learn vocabulary, sentence structure and phonology. This battery of language skills assessments sounds promising as a pre-diagnostic tool but is designed for children aged 42 months; in addition, it has been criticised for issues regarding inter-rater reliability (Hasson & Joffe, 2007) and is usually very time-consuming (De Lamo White & Jin, 2011).

Since 2013 the Health Visitors use general developmental questionnaires at age 2 which include language components, such as the revised Ages and Stages Questionnaires (ASQ: Squires & Bricker, 2009). However, each of these tools is designed and normed for monolingual development which, along with the lack of adequate language assessment tools for that age range, means that bilingual 24-month-olds continue to be at risk of under-referral (Crutchley, 2000; Salameh et al., 2002).

The linguistic heterogeneity of the UK regarding its bilingual population, and the clear clinical need, motivate the parallel aims of this paper: estimate the impact of language community and linguistic distance on bilingual lexical development, and thereby calibrate a new bilingual language estimation tool, the UKBTAT (UK Bilingual Toddler lAnguage Tool). The UKBTAT, designed to address issues faced by Early Years Practitioners in a range of bilingual situations, has the following characteristics: (1) it is targeted for 24-month old children, a milestone age easy to remember for parents and practitioners, and relevant for the UK policy of assessing children from this age; (2) it is usable for any child learning British English and any other Additional Language from our 13 target languages – and can also provide useful information regarding English development for children learning another Additional Language; (3) it is user-friendly and easy to administer, relying on short parental questionnaires about the child's vocabulary knowledge, and a 10-minute interview with the parent/carer (which can be done on the phone) to collect critical data on language exposure and demographics; (4) it provides interpretable results even if parents or carers estimate their child's knowledge of English only, although the added information about the Additional Language, when available, enriches the outcome; and (5) it can be used by a non-SLT practitioner, it is freely accessible online on a dedicated website and easily printable if needed.



The UKBTAT is based on data collected in a large-scale survey of bilingual toddlers across the UK, sampling 372 children learning British English and one out of 13 target Additional Languages (Bengali, Cantonese, Dutch, French, German, Greek, Hindi/Urdu[1], Italian, Mandarin, Polish, Portuguese, Spanish, and Welsh), and an additional 58 learning British English and another Additional Language (trilinguals and other multilinguals were excluded). For each child, we collected vocabulary data in English and in the target

Additional Language, together with detailed information about family composition and characteristics, and level/mode of exposure to English. Many studies have examined situational factors that could impact the rate of language development in bilingual children, including socio-economic status (e.g. Calvo & Bialystok, 2014; Gross et al., 2014), relative amount of exposure to each language (e.g. Hoff et al., 2014), mode of exposure, such as number of speakers per language (e.g. Gollan, Starr & Ferreira, 2015), daycare attendance (e.g. Hansen & Hawkes, 2009), or language mixing (e.g. Byers-Heinlein, 2013). Such studies typically focus on no more than three factors at a time, making it difficult to quantify the relative contributions and interactions of all factors on a single measure of language achievement. A recent exception is the 250-children study by O'Toole et al. (2017), who compared vocabulary in six groups of bilingual children aged 24 to 36 months growing up in different countries (Maltese-English, Polish-English, French-Portuguese, Hebrew-English, Irish-English, Turkish-German) using adaptations of Communicative Development Inventories (CDIs), and examining the contribution of a range of situational factors to TCV measures. They reported some large, unexplained variations in TCV measures across language groups, possibly due to linguistic distance, with for example Maltese-English and Polish-English groups scoring lower than the other groups. However because they tested children from a range of linguistic, cultural and geographical backgrounds, it is impossible to disentangle variance due to any of these factors from that due to linguistic distance.

The current study is the first extensive study of the effects and interactions of the potentially critical factors for language development in bilingual toddlers learning one common language: relative exposure to L1 and L2, family demographics, mode of exposure (which uncovers a range of factors, as described below) and, innovatively, language community (i.e., the specific Additional Language being spoken) and linguistic distance between English and the Additional Language. Quantifying the contributions of these factors to the trajectory of vocabulary development in bilingual toddlers will be critical to provide an accurate picture of expected language outcomes at 2 years.

Here we present the data and analyses for our original cohort of 372 toddlers who heard both English and one of the target Additional Languages (Chapters 4 and 5), followed by the final design and equations for the UKBTAT (Chapter 6). Importantly, we show that the models that fit the original cohort generalise to an additional dataset (the 58 toddlers learning English plus a non-target Additional Language), revealing the robustness of the predictive power of our set of measures. In addition, the fact that the models extend to a group of children learning English and a non-target Additional Language shows that our approach is suitable across the population of British English/Additional Language bilinguals. These two challenges - generalising beyond sample and across languages - were the primary targets of our project.

Before introducing the data and the UKBTAT, we review in Chapter 2 the potential factors that influence vocabulary knowledge at age 2 in bilingual toddlers, and discuss issues pertaining to language community and linguistic distance in Chapter 3.

## Chapter 2 - Factors Influencing Bilingual Vocabulary Development

### Relative Amount of Exposure to L1 and L2

It is firmly established that the relative exposure to each language strongly influences bilingual children's rate of development in those languages (Welsh: Gathercole & Thomas, 2009; Spanish: Hoff et al., 2012; Pearson, Fernandez, Lewedeg, & Oller, 1997; French: Thordardottir, 2011; Cantonese and Mandarin: Law & So, 2006); indeed, relative exposure has been advocated as a proxy for language dominance (Unsworth, 2012). Relative exposure predicts development of phonology (Law & So, 2006), lexicon (Cattani et al., 2014) and grammar (Gathercole, 2002a; 2002b; 2002c; Nicholls, Eadie, & Reilly, 2011; Oller & Eilers, 2002). How to measure the exposure to each language varies from one study to the next or from one lab to the next, for example asking parents to use a prospective language diary (e.g. De Houwer & Bornstein, 2003; Place & Hoff, 2011), or using a detailed questionnaire or interview about regular exposure to each language (e.g. ALEQ: Paradis, 2011; Language Exposure Questionnaire: Bosch & Sebastián-Gallés, 1997; Thordardottir, 2011; Hoff et al., 2012). Because these questionnaires tend to be long and complex to administer, we developed our own Language Exposure Questionnaire tool (referred to as LEQ; Cattani et al., 2014), consisting of a 5 to 10 min interview with the parent (face-to-face or on the phone), comprising 10 to 12 simple questions about a child's typical week. In a group of 35 mixed bilinguals aged 30 months, Cattani et al. (2014) showed that the amount of exposure as measured by the LEQ predicted vocabulary scores in comprehension and production as measured by the Oxford CDI (Hamilton, Plunkett, & Schafer, 2000): specifically, the more exposure to English (relative to the Additional Language) children experienced in a typical week, the more words they understood and used in English. Recently, Abdelwahab, Stone, Slee, Cattani and Floccia (2016) also showed a strong correlation between LEQ scores and three other widely-used questionnaires (ALEQ: Paradis, 2011; MLEQ: Yang, Blume, & Lust, 2006; Language Exposure Questionnaire by Bosch & Sebastián-Gallés, 1997), with correlations ranging from .62 to .79.

The LEQ primarily collects information about speech directed towards children, as the consensus is that children's language development benefits from joint attention situations (e.g. Tomasello & Farrar, 1986) and infant directed speech (Weisleder & Fernald, 2013). However, in many cultures children are not directly addressed (Lieven, 1994), and recent studies have showed that word learning at 18 months, for example, can be elicited from overheard speech (Floor & Akhtar, 2006). Furthermore, bilingual infants as young as 3.5 months benefit from overheard speech in their ability to discriminate between their two native language(s) (Molnar, Gervain, & Carreiras, 2014). In fact, in many tools used to quantify the relative amount of exposure to each language, both direct (speech to the child) and indirect (speech between adults) sources are taken into account in the calculations (e.g., Paradis, 2011; Yang et al., 2006). To complement the LEQ measure and ensure that we quantify all possible sources of English/Additional Language input, the proportion of British English versus Additional Language used in overheard speech between parents was also evaluated in the current study.



**Mode of Exposure**

Mode of exposure is probably the most complex factor to estimate, as it includes a range of variables such as the *source* of each language (e.g. presence of siblings, number of speakers per language, social context of exposure, e.g., crèche versus home), the *status* of the languages in the environment (minority language, such as Mandarin in a Plymouth family, or predominant cultural bilingualism as Welsh and British English in Bangor), and the *quality* of the input (language mixing; native versus non-native input). It is a current matter of debate whether these variables have a significant effect on bilingual language development, especially in toddlers.

**Source of each language.** The bilingual child's relative proficiency between languages appears to be modulated by the source of exposure, i.e. who is speaking to them in each language. For example, Barrena, Ezeizabarrena and Garcia (2008) reported that Basque-Spanish young bilinguals knew more words in the Additional Language (Basque) when both parents were Additional Language speakers as compared to when only one was an Additional Language speaker - although this factor could be confounded with the amount of exposure in this study. It is also possible that there may also be differences depending on *which* parent is the source of Additional Language[2]. Fathers generally direct less verbal output to their child than mothers, as they spend a greater proportion of their time interacting through play activities, especially physical play, which reduces the density of their speech (e.g. Pancsofar & Vernon-Feagans, 2006).

More generally, the effect of the number of speakers per language has recently been studied (e.g. Gollan et al., 2015), given theoretical proposals that variability in speech input supports the construction of phonological categories in early infancy (e.g. Rost & McMurray, 2009; Singh, 2008). Place and Hoff (2011) report that 25-month-olds Spanish-English bilinguals knew more words in English if they interacted with a larger number of speakers in that language, once corrected for the overall amount of exposure to English (see also Gollan et al., 2015). However, this finding was only partially replicated in Place and Hoff (2016) with a larger sample of 90 30-month-olds learning Spanish and English, where modest speaker number effects were found, predictive of knowledge in Spanish only. In the current study, we will therefore examine the effect of vocabulary scores on the number of speakers per input language.

The impact of daycare attendance on children's development is a longstanding question in child development research, with mixed data (e.g. Brooks-Gunn, Han & Waldfogel, 2002; Ruhm, 2004). One of the few consistent overall results is that daycare attendance tends to benefit children from low SES. For example, using data from about 13,000 children in the British Millennium cohort, Côté, Doyle, Petitclerc and Timmins (2013) report a cognitive advantage at age 3 for children who have attended daycare, but only for those from low SES, and only below age 5. However, Hansen and Hawkes (2009), using the same cohort data, show that vocabulary outcomes are not significantly affected by daycare, with the exception of grandparent care which benefit mainly children from higher SES families. We will measure how vocabulary outcomes are modulated by daycare attendance and language spoken within that environment.

The presence of older siblings is another potential source of variation. In monolingual homes, first-born children tend to acquire language faster than later born siblings (e.g. Fenson et al., 1994, 2007, for production; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 2010), presumably because they get more joint attention opportunities with adults and because child-directed speech produced by adults is of better quality than that produced by children. For bilingual children, this should result in a larger vocabulary in both languages for first-borns than later children. However, Bridges and Hoff (2014) found that North American bilingual toddlers with older siblings were more proficient in English compared to other bilingual children with no older siblings, presumably because older bilingual siblings were more likely to use English when addressing toddlers than other members of the family. Therefore, although input from older siblings may contain more ungrammatical structures and less diverse vocabulary, it nonetheless tends to contain a higher proportion of English, thus leading to higher levels of English vocabulary in the target children. Here we will examine whether the number of older siblings at home has any effect on vocabulary development and especially English production skills.

**Quality of the input.** We use quality of input to refer to whether children are presented with an input free of language mixing, and whether it is produced - or not - by a native speaker. Language mixing or switching (including elements of each language at the sentence level, or, in a broader sense, at the discourse level), which is estimated to occur significantly often for many bilingual children (e.g. over 20%: Tare & Gelman, 2011; between 2 and 10%: Nicoladis & Secco, 2000), is potentially a delaying factor in language development (especially language mixing at the sentence level), as language acquisition theorists usually argue that language separation early in development should be favoured by learning mechanisms (e.g. Curtin, Byers-Heinlein, & Werker, 2011). However, mixed results have been observed. Place and Hoff (2016) tested ninety 30-month-old Spanish-English bilingual children (see also Place & Hoff, 2011), and after controlling for gender, maternal education, and the child's relative language exposure, they reported no robust relations between the frequency of mothers' use of the two languages (measured at the discourse level, not within sentences) and measures of their children's English or Spanish skills. They concluded that the negative effect of the parental habit of code switching may be minimal on children's language development or perhaps influential only at the very early stages of language development. Indeed, Byers-Heinlein (2013) found that intra-sentential language mixing was detrimental at 18 months, but only marginally at 24 months. Thus, we also assess the effect of parental language mixing on our target population of bilinguals. One possibility, which we will examine here, is that the negative impact of parental language mixing on vocabulary development (Byers-Heinlein, 2013) might be mainly found for pairs of languages with a minimal phonological overlap, as Byers-Heinlein primarily examined distant language learners whereas Place and Hoff (2016) looked at close language learners.

Another qualitative aspect of the input that might modulate bilingual children's vocabulary growth, is the nativeness of the adult speaker in each language. The hypothesis that native speakers provide more supportive input in their language than non-native speakers is a matter of controversy. Fernald (2006) suggested that being presented with both native and non-native speech in their two languages could lead infants to have more difficulties in discriminating between them, and subsequently impair development of phonological categories (young bilinguals do learn some phonological contrasts later than monolinguals: Bosch & Sebastián-Gallés, 2003; Burns, Werker, & McVie, 2003). It could be also that non-native speakers tend to use less varied vocabulary (Hoff, Coard, & Señor, 2013). However, Paradis (2011) examined 4- to 7-year-old immigrant children in Canada and found that mothers' proficiency in English was not a significant predictor of children's English vocabulary. In contrast, Hammer et al. (2012) reported that for Spanish-English 59-month-old bilinguals, English proficiency of mothers was a fair predictor of their children's scores in English tests, although they did not control for the relative exposure to English/Spanish. Place and Hoff (2011) reported that in 29 Spanish-English bilinguals aged 25 months, English vocabulary was positively correlated with the amount of English produced by native as opposed to non-native speakers, controlling for overall exposure. More recently, Place and Hoff (2016), with a larger sample of 90 30-month-old Spanish-English bilinguals, also reported a small but positive influence of the proportion of native-speaker input on English knowledge when measured with standardised tests (PLS-4: Zimmerman, Steiner & Pond, 2002; EOWPVT: Brownell, 2001). They found no effect on CDI measures, however. We will examine if the proportion of parental native versus non-native speech has an effect on children's vocabulary size in each language.

**Status of the Additional Language.** Whether children grow up bilingual in a monolingual or bilingual society may have consequences for their degree of achievement in both languages. Bilingual children from minority populations such as recent immigrants (e.g. Cantonese/English speakers in the UK) tend to have lower academic outcomes in mainstream education than monolinguals (Prevoo Malda, Mesman, & van IJzendoorn, 2016), likely driven by poorer English reading comprehension skills. This disadvantage is particularly acute if English is not their dominant language (Strand, Malmberg, & Hall, 2015). In contrast, when bilingualism is the norm within a particular society, such as in certain Welsh communities, the cognitive and academic achievements of bilingual children can be equal (Rhys & Thomas, 2013) or even better (i Trueta, Barrachina, & Pascual, 2012) than their monolingual peers. Thus, in a bilingual society children's achievements in both their languages might be advantaged, as compared to children learning English and an Additional Language in a monolingual community. We will explicitly test this hypothesis through the inclusion of a target cohort of Welsh-English toddlers (N=63) selected from a bilingual community in North Wales.

**Demographic Factors (SES and Gender)**

Monolingual children from lower socio-economic groups tend to have poorer language skills than those from higher SES (Deutsch, 1965; Hoff-Ginsberg, 1998; Rack, Snowling, & Olson, 1992), perhaps because of the characteristics of maternal input (Hoff, 2003) and/or the home attitude towards literacy (Payne, Whitehurst, & Angell, 1994), which includes low frequency of shared reading activities at home (Britto, Fuligni, & Brooks-Gunn, 2002; see Tomalski et al., 2013, for showing that SES shapes brain activity in early infancy). Unsurprisingly, this SES related language advantage also extends to bilingual children (e.g. Calvo & Bialystok, 2014; Gathercole, Kennedy, & Thomas, 2016; Hoff, 2013; Ollers & Eilers, 2002; Paradis, 2009). It has similarly been proposed that this effect is partially due to the higher quality of language provided by mothers with a high education background, improving their children's acquisition of the maternal language, and transferring to an advantage in the Additional Language even if the mother does not use it (Goldberg, Prause, Lucas-Thompson, & Himsel., 2008; Paradis, 2009).

It is important to note however, that in monolingual toddlers the effect of SES on vocabulary size as measured by CDIs is heavily dependent on the presence of children from *very low* SES backgrounds in the sample. Where such children are not systematically recruited there are negligible or null effects: for example, in the latest cohort tested with the MacArthur CDI (Fenson et al., 2007; N = 2007), no effect of SES (as measured by maternal education) was found between 13 and 20 months, and significant but very small effects were reported in production from the age of 21 months onwards. The original MacArthur CDI cohort (Fenson et al., 1994; N = 1130) found a very small correlation between SES and vocabulary production in 16-30 months old toddlers (r = .05). Similarly, in the Oxford CDI, Hamilton et al. (2000) did not find any correlation between SES and vocabulary scores in production or comprehension. In contrast, the studies of Fernald, Marchman and Weisleder (2013) and Arriaga, Fenson, Cronan and Pethick (1998), which sampled extensively from low SES families, demonstrated significant if modest SES effects.

This pattern of findings suggests that the effect of SES may be limited to the lower thresholds, or below, of SES indexing. As with the Fenson et al. (2007) and Hamilton et al. (2000) studies, the current study had an under-representation of low SES children within our bilingual cohort. This may be representative of SES distribution across the national population of bilingual children: Dustmann and Frattini (2011), using a variety of large scale British and international sources collected between 1993 and 2009, observed that immigrant populations in the UK tend to leave the education system later and have higher wages than their native peers. It is also likely that this under-representation stems from sampling, with low SES bilingual families reluctant to take part in research, especially in cases when they are not confident in English.

Gender is also a well-documented factor in vocabulary growth, with girls usually producing more words than boys (Huttenlocher et al., 1991), without necessarily showing better comprehension scores than boys (girl advantage in Fenson et al., 2007; equal levels in Eriksson et al., 2012). In the original MacArthur CDI cohort of 8- to 30-month-olds (Fenson et al., 1994), gender was found to account overall for 1 to 2% of the variance, and more in production than comprehension. This production advantage for girls was found to be consistent across linguistic communities as demonstrated with CDI data collected from 10 large non-English groups (Eriksson et al., 2012), pointing to a common neurophysiological explanation rather than sociological/cultural causes - or perhaps to widely shared conventions of encouraging more communication with girls.

To summarise, we have reviewed the range of situational factors which might shape vocabulary knowledge in bilingual toddlers: relative amount of exposure, mode of exposure (an umbrella term for a range of factors related to the source of the Additional Language, the quality of the input, and the Additional Language status) and demographic factors. In the next chapter we will discuss the impact of additional variation linked to the diversity of language pairs.

## Chapter 3 - Language Community and Linguistic Distance

Most bilingual studies are conducted with homogeneous samples, with Spanish-American English bilinguals constituting the largest cohort (e.g. Marchman, Fernald, & Hurtado, 2010; Place & Hoff, 2011), followed by Canadian English-French (e.g. Paradis, Crago, Genesee, & Rice, 2003), Barcelona Catalan-Spanish (e.g. Bosch & Sebastián-Gallés, 2001) and Welsh-British English (e.g. Gathercole & Thomas, 2009). It is a general assumption that results obtained with one L1-L2 pairing are generic, and can be exported to different L1-L2 pairs. Is it safe to assume, however, that bilingual children from different backgrounds are confronted with the same linguistic problems to solve, or that they are able to solve them within the same learning span?



There is growing evidence that, according to the language they acquire, monolinguals' learning paths can differ, including for early lexical prosodic processing (Adam & Bat-El, 2009), word segmentation (across dialects: Floccia et al., 2016; Nazzi, Mersad, Sundara, Iakimova, & Polka, 2014), and phonological processing (Nazzi, Floccia, Moquet, & Butler, 2009; Mani & Plunkett, 2007; Delle Luche, Floccia, Granjon, & Nazzi, 2016; Bouchon, Floccia, Fux, Adda-Decker, & Nazzi, 2015), culminating in differences in vocabulary growth (Bleses et al., 2008; Thordardottir, 2005). Bilingualism is likely to exacerbate these language-specific differences, adding not only a new language but also the complexity of interactions between languages (the so-called non-separability, or non-selective access issue; e.g. French & Jacquet, 2004). Interaction between the two language systems is perhaps most obvious in production, where code-switching is frequently observed in toddlers at the phonological, lexical and morphosyntactic level (e.g. Gildersleeve-Neumann, Kester, Davis, & Peña, 2008; Paradis & Genesee, 1996). Non-selective lexical access in comprehension, as demonstrated in adults (e.g. Dijkstra, 2005), is evident at least from three years of age (e.g. Poulin-Dubois, Bialystok, Blaye, Polonia, & Yott, 2013; Von Holzen & Mani, 2012; see the review by DeAnda, Poulin-Dubois, Zesiger, & Friend, 2016). However, even if there were an earlier separation of lexicons, bilinguals would still demonstrate language-specific differences from the parallel learning of two language systems. For example, French infants rely more on consonants than vowels for lexical processing from the age of 8 months (Nishibayashi & Nazzi, 2016), whereas British English learners process consonants and vowels equally (Mani & Plunkett, 2007; Floccia, Nazzi, Delle Luche, Poltrock, & Goslin, 2014), at least until the age of 30 months (Nazzi et al., 2009), and Danish children rely more on vowels than than consonants at 20 months of age (Højen & Nazzi, 2016). How do such differences translate to the case of bilingual learners? Will language-specific routes for vowel-consonant processing be delayed until the onset of separate language processing, or will one linguistic strategy be adopted, at an efficiency cost to the other language?

In sum, each language pairing will necessarily produce a different linguistic learning problem for bilingual infants to solve, which is likely to translate to variable delays and/or adapted pathways (see Polka, Orena, Sundara, & Worrall, 2017, for word segmentation outcomes differing in bilingual and monolingual 8-month-olds). In this project we will make the first systematic evaluation of the impact of differences between languages, as measured through metrics of linguistic distance, on vocabulary acquisition in both British English and the Additional Language.



**Measuring Linguistic Distance**

As adults, second language learning seems easier if the language is intuitively similar to our own (e.g., English/German vs English/Cantonese), which is supported by studies in second language learning for both adults and school-aged children (e.g., Lado, 1957; Lindgren & Muñoz, 2012; Van der Slik, 2010). For example Lindgren and Muñoz (2012) showed that a cognate-based measure of language distance is the most important predictive factor for formal second language learning in schools, above differences in the exposure of the languages at home. These results support the idea that in second-language learning, the knowledge and structure of L1 provide scaffolding for the acquisition of L2.

However, in early simultaneous bilinguals the effects of language distance are more complex as the languages are acquired in parallel from infancy. While similarities between L1 and L2 may reinforce phonological, lexical and syntactic acquisition across the two languages, it would also reduce the perceptual separation between languages. Knowledge of the interaction between reinforcement and separation is crucial to our understanding of bilingual acquisition, but the complexity of multi-dimensional representations of language mean that unitary measures of the seemingly intuitive notion of 'linguistic distance' are difficult to evaluate. This complexity is reflected in the many distance metrics which have been proposed, including cognate distance (e.g., Dyen, Kruskal, & Black, 1992), genetic linguistic distance (Harding & Sokal, 1988; Ruhlen, 1987), phonetic distance (Nerbonne et al., 1996), distance in terms of linguistic rhythm (Ling, Grabe, & Nolan, 2000; Ramus, Nespor & Mehler, 1999) and second language learnability (Chiswick & Miller, 2005).

Of all linguistic distance measures, cognate distance is probably the metric that has the widest currency, at least at the lexical level. Traditionally, this refers to the proportion of translation equivalents sharing common historical origins, such as *lait* in French and *leche* in Spanish (*milk*, sharing the Latin root *lac*). In an influential cognate database (e.g., Dyen et al., 1992, adapted by McMahon & McMahon, 2005), the index of linguistic cognate distance is obtained from the compilation of 200 frequent culture-neutral words in 84 Indo-European languages and dialects, and for each language pairing. However, the definition of cognates in Dyen et al.'s database makes it difficult to generalise to languages without a clear common history. Approaches based on automatic methods have been proposed to refine the definition of cognates, for example by using intra-language similarity (Ellison & Kirby, 2006) or cross-language orthographic similarity measures (Serva & Petroni, 2008). While some of these metrics may be suitable for the adult speech environment, child-directed speech differs in lexical, prosodic and pragmatic content from adult-directed speech (e.g. Thiessen, Hill, & Saffran, 2005). Importantly, infants do not share adults' meta-linguistic and orthographic knowledge.

Given the young age of our participants it was necessary to base our distance metrics on a set of child-familiar basal words and to consider phonetic, phonological and metrical similarities rather than historical origins or orthographic properties. To this end we developed a measure of linguistic distance which focussed upon corpora related to toddlers' speech environment. We used the Oxford CDI (Hamilton et al., 2000), which supplied us with a list of words that should be known to British English children of our target age group. To produce vocabularies for the 13 target Additional Languages, we could have adopted a similar procedure, using the words listed in each language-specific CDI as a proxy of toddler vocabulary for each Additional Language. However, these CDI vocabularies would largely reflect the cultural and physical environment in which the language was predominantly spoken. As our bilinguals all live in the UK it is likely that both their British English and Additional Language vocabulary would reflect a British English environment, rather than the environment of the monolingual Additional Language CDI. As such, we believe that the bilingual Additional Language lexicon would be better represented by translation equivalents of the words of the Oxford CDI. This approach also has the advantage that it is unaffected by variations in the methodologies used to construct Additional Language CDIs, which can result in wide differences in CDI word counts. Details of these toddler-centric metrics can be found in the method section (Chapter 4).

In addition to measures of linguistic distance based on lexical overlap, we also ranked language pairs on measures of grammatical distance, namely word order typology and morphological complexity. Languages can be broadly distinguished on the basis of the relative order of the main verb (V) and its object (O) (Dryer, 1991; Greenberg, 1963), with VO order for e.g. English and Spanish, OV for e.g. Bengali and Hindi/Urdu and mixed OV/VO for German and Dutch. Children's very first combinations of words show knowledge of this basic word order (e.g. Bates et al., 1984; Brown, 1973), demonstrated even earlier in comprehension (e.g. Höhle, Weissenborn, Schmitz, & Ischebeck, 2001), although the full knowledge of native language word order patterns takes several years to develop (e.g. Abbot-Smith, Lieven, & Tomasello, 2008; Akhtar & Tomasello, 1997; Guasti, 2002). To retrieve information about their language's syntactic typology, monolingual infants have been found to rely on the relative order of function and content words in their first year of life (Gervain, Nespor, Mazuka, Horie, & Mehler, 2008), as well as on prosodic correlates of word order (Bernard & Gervain, 2012; Christophe, Nespor, Guasti, & Van Ooyen, 2003). In bilingual infants, Gervain and Werker (2013) recently showed that when learning languages with opposite word orders, e.g., English and Hindi, 7-month-old bilinguals would also exploit the appropriate prosodic information, revealing an early sensitivity to cues that can be used to acquire basic word order in their two languages. Once acquired, knowledge of word order would logically boost word segmentation and grammatical parsing, and therefore learning two languages with a common word order might facilitate these processes. We will examine whether vocabulary scores in English and in the Additional Language at the age of 2 can be predicted from the similarity of British English and the Additional Language in terms of word order typology.

Finally, languages can also be ranked on a continuum of morphological complexity (Brown, 2010; Comrie, 1989; Greenberg, 1960), with analytic or isolating languages on one end of the continuum (lowest ratio of morphemes to words, as in Cantonese, and to a lesser extent, in English), inflecting/fusional (Russian, Italian, French) as well as agglutinating

(Finnish, Basque, Turkish, Hungarian) languages in the middle, and polysynthetic languages on the other end (highest ratio of morphemes to words, such as in Yupik). The most intuitive expectation is that speed of acquisition would vary as a function of the morphological complexity of the to-be-acquired language (see Caselli, Casadio, & Bates, 1999, for this suggestion). Xanthos et al. (2011) found, by contrast, that the more morphologically complex the ambient language, the faster children will acquire morphological rules (see also Leonard, 2000). However, it is possible that the nature of the cognitive resources engaged in language acquisition vary as a function of its morphological complexity, with analytic languages making greater demands on memory than synthetic languages (Fortescue & Lennert Olsen, 1992). In the bilingual situation, acquisition could be boosted when confronted with morphologically close pairs of languages as compared to more distant ones, simply because of a better alignment of cognitive demands. We will evaluate whether vocabulary scores in English and in the Additional Language can be predicted from the proximity of languages in terms of morphological complexity.

**Language Community and Culture**

In addition to linguistic distance, each language pairing also comes with a range of cultural and social idiosyncrasies, which are impossible to explore exhaustively and often difficult to disentangle from linguistic factors. Studies which have attempted to examine the combined or separate effects of cultural and linguistic variations in early language development are, to our knowledge, very scarce. One such study by Barac and Bialystok (2012) compared four groups of 6-year-olds: English monolinguals, Spanish-English, French-English and Chinese-English bilinguals, all attending similar schools in Canada. When controlling for SES and the amount of exposure to each language at home, it was found that Spanish-English bilinguals outperformed French-English and Chinese-English children; however, French-English children were the only group whose schooling was in French, whereas the other groups received English schooling. This study at least allows us to conclude that cultural and linguistic factors probably conspired to explain the gap between Spanish-English and Chinese-English bilinguals. Similarly, Bialystok, Majumder and Martin (2003) showed an advantage for metalinguistic awareness in Spanish-English bilinguals at 6-7 years of age, as compared to English monolinguals; Chinese-English bilinguals performed worse, however, which could again be due to a combination of cultural and linguistic factors.

*Disentangling the effect of linguistic distance from that of language community*

It is impossible to account for all variation associated with each language, and a fortiori, for each language pairing. In the current study we examined a large number of language pairs (13 pairs) with British English common across all pairs. Our sample provides variation in terms of linguistic distance and cultural background, as a subsample of all possible pairings. These data will be analysed with linear mixed models (LMMs) which include a factor for random variation due to language community, but also linguistic distance as a "between-language" fixed factor. If linguistic distance has an effect then it can be used to usefully explain some of the variance in scores that would otherwise simply be apportioned to language community.



**Assessing One or Two Languages**

As mentioned above, professional bodies such as the Royal College of Speech and Language Therapists recommend that bilinguals should be assessed in their two languages, as the variety of factors modulating bilingual development prevents a direct comparison of their achievements with corresponding monolingual norms (Kohnert, 2010). Our aim is to accommodate these factors to provide norms of development in English and 13 target Additional Languages, resulting in a screening tool which, based only on estimates of English vocabulary, would allow identification of possible language delays for any incoming Additional Language (avoiding the requirement for normed data on any new language pair).

The possibility of an English-only screening tool is based on two theoretical premises. First, in bilinguals, Developmental Language Disorder, as well as language-based learning disabilities, affect both languages (Håkansson, Salameh, & Nettelbladt, 2003), insofar as such disorders are underpinned by a genotype affecting neurophysiological processing (e.g. Leonard, 1987; Schwarz, 2010). The second premise is that, although not all late talkers in early childhood are going to develop a primary language impairment (e.g. Rescorla, 2005), almost all children diagnosed with DLD later in childhood had a history of initial language delay, in the form of protracted vocabulary development in comprehension and production (Conti-Ramsden et al., 1997). Hence, Dale et al. (2003) reported that monolingual 2-year-olds who scored below the 10th percentile on the MacArthur–Bates Short Form CDI in production were significantly more likely to be diagnosed as DLD when reaching the age of 3 to 4 years. Out of the 6,500 children who scored above the 10th percentile for vocabulary production at 2 years, only a tiny fraction exhibited grammatical difficulties one or two years later. Early receptive language difficulties have an even higher predictive validity of later language disorder diagnosis (e.g. Beitchman et al., 1994; Chiat & Roy, 2008).

The corollary of these two premises is as follows: if we could detect the late bilingual talkers at age 2 years in English only, when all other sources of variation have been factored in, we would have identified the main cohort from whom language impaired children will be diagnosed one or two years later. While we agree that collecting information about a bilingual child's language development in both languages is still relevant and informative for clinical and research purposes, practitioners or researchers might not always be familiar with both languages. Thus the ability to work with only one of the two languages of a bilingual is important from a theoretical as well as a practical point of view.

## Chapter 4 - Collecting Vocabulary Data in Bilingual Toddlers: Objectives and Methods

A sample of 430 bilingual toddlers, learning British English and one of 13 target Additional Languages (N = 372) or any other Additional Language (N = 58), were identified over a 2-year period. To increase variation in both English/Additional Language pairs and in the situational factors outlined above (language exposure, mode of exposure and demographic factors), data was collected through RAs recruited in the six universities involved in this project (Bangor, Birmingham, Kent, Liverpool, Oxford and Plymouth), each having access to multilingual populations to various degrees. However, since the testing platform was remotely accessible, the final sample comprised families from all areas of the UK, apart from Scotland and Northern Ireland. Bangor had the additional advantage of being located in a region with 75% bilingual Welsh-English children, providing a unique opportunity to compare language skills in bilinguals growing in a region with predominant bilingualism, to those whose bilingualism is linked to immigration.

When the child approached her second birthday, volunteer parents were contacted via the website UKBilingualToddlers, and the following data were collected in this order: English expressive and receptive vocabulary as measured through a bespoke Oxford Short Form CDI (Hamilton et al., 2000); Additional Language vocabulary as measured through the corresponding version of the CDI, when available; a family questionnaire with detailed questions about demographics (developed for the UK-CDI standardisation project, Alcock et al., in prep); and the Plymouth Language Exposure Questionnaire (Cattani et al., 2014).

To sum up, the current study measured four parent-assessed outcome variables at 24 months: receptive English vocabulary, expressive English vocabulary, receptive Additional Language vocabulary and expressive Additional Language vocabulary. For each of these outcome variables, we investigated the influence of the following factors: 1) gender, 2) SES (as assessed via parental income and educational level), 3) proportion of child-directed speech in English (LEQ), 4) proportion of overheard parental peech in English, 5) factors related to the source of each language (whether two parents are native Additional Language speakers or only one, number of sources of English, number of sources of the Additional Language, time in daycare in each language, number of older siblings), 6) factors related to the quality of the input (degree of code-switching in the input, number of native and non-native speakers in each language), 7) status of the Additional Language (societal vs. minority), 8) the particular language community (i.e. which of the 13 additional languages the child was exposed to) and 9) the linguistic distance between English and the Additional Language as measured by a) phonological distance, b) morphological distance and c) syntactic distance (see Table 2 for a summary of these variables).

**Key Predictions and Research Questions**

1. Given the solid evidence of the importance of the amount of language exposure in expressive and receptive vocabulary growth (e.g. Hoff, 2003), we expected this factor to be a robust predictor. In particular, we predicted that children with more exposure to English would have higher scores in both receptive and expressive vocabulary scores in English - and conversely, lower vocabulary scores in the Additional Language. We predicted that these effects would be strongest in our measure of direct exposure, the LEQ, but might also be found in our measure of indirect exposure via overheard conversation between parents (referred to as Overheard speech).

2. We predicted an effect of gender with girls outperforming boys (Eriksson et al. 2012), especially in expressive vocabulary (Fenson et al., 2007).

3. SES was expected to modulate language outcomes with smaller expressive and receptive vocabularies for children from lower SES families (Gathercole et al., 2016).

4. Regarding the effect of those factors related to the mode of exposure to each language (source, quality and status), one objective of this study was to assess whether effects described in the literature for specific English-Additional Language pairings are robust over a range of languages.

5. The effect of Language Community is an unknown variable, and is expected to generate a large degree of unexplained variance, due to a variety of cultural and linguistic factors. In our LMMs, Language Community is treated as a random factor to acknowledge that our 13 target languages comprise a non-exhaustive sampling of possible language pairs. The success with which the random effects modelling will produce a model that generalises beyond these target languages will be assessed by establishing how well our models generalise to a test set of 58 children whose Additional Language is not part of our 13 target languages, and therefore not represented in the model.

6. Additionally, however, we hypothesise that part of the variance attributed to Language Community can be accounted for by Linguistic Distance between British English and the Additional Language, as measured by the phonological overlap between translation equivalents, the word order typology and morphological complexity.



**Method**

**Participants.** Data were collected for a total of 430 children between February 2014 and July 2016. The data of an additional 31 children were discarded as they had hearing problems (N = 7), had a diagnosed developmental delay (as reported by parents; N = 6), were too young or too old (N = 17), or had incomplete records (N = 1). Data were collected by trained research assistants at the Universities of Bangor, Birmingham, Kent, Liverpool, Oxford and Plymouth, as well as two research assistants located in Bristol and Leicester respectively. Out of the remaining final sample of 430 children (aged 23.89 years, SD 0.39, from 23.0 to 25.0; 193 girls and 237 boys), 372 were learning English and one of the 13 target Additional Languages, while the remaining 58 were learning English and one non-target Additional Language (see Table A4 in appendix 4). Out of these 430 children, the information for family income (an optional field) was not supplied for 15 children (13 in the target language community and 2 in the non-target language community). See Table A6-1 in appendix 6 for a full description of the sample.

**Procedure and instruments.** The data collection was initiated when the children reached 23.5 months old. When signing the online consent form on the UKBT database, parents were notified that there were four tasks to complete for the study: none of these tasks involved testing the children, allowing for remote data collection. When signing up, contact information and identification of the language(s) being spoken at home triggered the selection of the appropriate Additional Language CDI when available.

***Metrics of linguistic distance.*** To create a toddler-centric representation of language distance, each of the 406 non-onomatopoeic words from the Oxford CDI (Hamilton et al., 2000), as well as their translation equivalents across the 13 target Additional Languages, were transcribed into broad phonological representations. These were produced by trained phoneticians, each of whom was a native speaker of the language they were asked to transcribe. Our metric of language distance was then calculated as the overlap between the phonological representation of a word in British English and its translation equivalent in the Additional Language. This overlap was based upon the Levenshtein distance, that is, the minimal number of insertions, deletions and translations that are required to get from the British English phonological representation to that of the Additional Language. To produce a proportional measure of overlap this distance was subtracted from the length of the longest phonological sequence in British English or Additional Language, and then divided by the same number. This produces a measure of phonological overlap for each word, between 0 (no overlap) and 1 (perfect cognate), that preserves sequence order and is proportional to the length of the word.

$$Overlap = \frac{Max(BE\ length,\ AL\ length) - Levenshtein\ distance}{Max(BE\ length,\ AL\ length)}$$

An example of a calculation for the British English word “lamp” and its Italian translation equivalent “lampada” is shown below:

**BE** lamp /l.æ.m.p/ : Sequence length = 4

**Italian** lampada /l.a.m.p.a.d.a/ : Sequence length = 7

Levenshtein distance (l.æ.m.p, l.a.m.p.a.d.a) = 4 (1 translation + 3 insertions)

$$Overlap = \frac{Max(4,7) - 4}{Max(4,7)} = 0.43$$

The language level phonological overlap between British English and each of the 13 Additional Languages is shown in Table 1, calculated as the average overlap across all 406 words.

For the measure of word order typology, the Additional Language was assigned a 1 if it had a VO order like British English, a 2 if it had a mixed VO/OV order, and a 3 for a OV order (see Table 1). Finally, morphological complexity was assessed on a 3 point scale, with analytic/isolating languages (Mandarin, Cantonese) being ranked closer to English (value 1), followed by fusional languages such as French and German (value 2) and agglutinative languages such as Hindi/Urdu and Bengali (value 3) (see Table 1).

INSERT TABLE 1

***Collecting demographic data.*** Demographic data were collected through the family questionnaire developed by Alcock et al. (in prep). This contains questions regarding (i) the health and development of the child, (ii) the child’s family history, (iii) parental information (e.g. parents' educational level, income and postcode), and (iv) childcare arrangements. Some of these questions were repeated in the LEQ (see below), but we tolerated overlap in order to retain each questionnaire's integrity. Following Arriaga et al. (1998), we focused on household income and educational levels when measuring SES, as typical indices of SES are highly correlated. Income was divided in four bands (variable Income), and education was measured on a seven point band that correspond to English qualification classifications, from no qualifications to a postgraduate degree (variables MumEd and DadEd; see appendix 2). Education was chosen as it is generally used as a proxy for SES (e.g. Bornstein, Hahn, Suwalsky, & Haynes, 2003; Fenson et al., 2007), and it is usually a better predictor of language development than income (e.g. Hoff, 2003); in addition we estimated that in the case of immigrant families, educational level might better reflect the child's learning environment than mere economic circumstances. The educational status of both parents was used since the correlation between these two predictors was not large (r = .29).

***Evaluating amount of exposure to each language.*** The Language Exposure Questionnaire (LEQ, Cattani et al., 2014) was used to obtain the percentage of direct language exposure received by the child in English and the Additional Language in a typical week based on a unique 5 to 10 minute phone interview. The questionnaire (available at http://www.psy.plymouth.ac.uk/leq/) requested information about (i) the average number of hours spent by the child in nursery/with a childminder in each language environment (variables EngDaycare and ALDaycare); (ii) the language(s) spoken by each parent at home and the relative frequency of use of L1/L2 (variables MumPropEng and DadPropEng, measured on a 5-point scale); (iii) the number of hours spent by the child alone with each parent; (iv) whether the parents spoke equally with their child when both parents present; and (v) the number of hours of the child's sleep in a typical day (to evaluate the number of possible contact time during a week). The detail of these variables and calculations leading to the proportion of English vs the Additional Language in a typical week (variable LEQ) is found in appendix 3.

To obtain the proportion of English/Additional Language in overheard speech (variable referred to as Overheard speech), an added question (5-point scale) was inserted after the original LEQ (see appendix 2).

***Evaluating the mode of exposure (source, quality and status).*** Measures of the various factors underpinning the *source of each language* were derived from questions which were part of the initial sign up sheet, the family questionnaire and the LEQ. Straightforward measures based on individual questions were the identification of the type of family (binary score for two parents native Additional Language speakers or only one; variable FamLang), the number of hours per typical week in English or Additional Language daycare (EngDaycare and ALDaycare), and the number of older siblings living in the house (until the age of 18 years; variable Siblings). Regarding the number of speakers in each language, a score of 1 was given to each native speaker parent, each older sibling, and attendance to a form of daycare (variable SourcesEng and SourcesAL, with an observed range of 0 to 6; see appendix 2).

Regarding the *quality of the input*, the amount of language mixing from each parent was obtained through the questions in the LEQ asking parents to quantify on a 5-point scale their relative use of English and Additional Language. Specifically, a parent would obtain a 1 for always speaking Additional Language, 2 for usually speaking Additional Language, 3 for English and Additional Language half of the time, 4 for usually speaking English and 5 for always speaking English (variable MumPropEng and DadPropEng). Then the amount of switching would be recoded as a minimum of 1 if the answer to the above was a 1 or a 5; a 2 if the answer to the above was a 2 or a 4; and a maximum of 3 if the answer to the above was a 3 (variables MumSwitch and DadSwitch, averaged as Mixing).

The proportion of native/non-native speech produced by parents was calculated from the same question, in conjunction with whether the parent was a native speaker of Additional Language or not. That is, the number of hours spent with each parent during a typical week was calculated as: 168 (number of hours in a week) - total sleeping time - hours in daycare - hours alone with the other parent (variable A). Then, each parent's score on their respective PropEng variable (1 to 5) was re-expressed as a proportion from 0 to 1 (1 = 0, 2 = .25, 3 = .5, 4 = .75, 5 = 1) to obtain the proportion of English in their speech (variable B). The resulting amount of English in this parent's input was obtained by multiplying A by B. If this parent was a British English native speaker, then AB would correspond to the amount of native input, and if the parent was an Additional Language native speaker, AB would be the amount of non-native input. The final proportion of native English input across both parents (the variable PropEngN), was obtained by dividing the total amount of native English by the sum of native and non-native English. The proportion of native Additional Language input (the variable PropALN), was calculated with a similar logic (see appendix 2).

Finally, regarding *status of the Additional Language*, Welsh-English children growing up in Wales were coded as societal bilinguals, all others not.

***Measuring vocabulary.*** To measure children's vocabulary achievements in English and in their Additional Language for the 13 target languages, we used CDIs as they have long established reliability and validity for their use in monolingual and bilingual populations in research (Mancilla-Martinez, Gamez, Vagh, & Lesaux, 2016; Marchman, Thal, Dale, & Reznick, 2006) and for clinical assessment (e.g. Charman, Drew, Baird, & Baird, 2003; Heilmann, Weismer, Evans, & Hollar, 2005; Thal, DesJardin, & Eisenberg, 2007).

For the English CDI, we developed a 100-word version of the existing Oxford CDI (Hamilton et al., 2000), referred to as the Oxford Short Form CDI, by selecting words from the original 416 words which would (1) be representative of the words known and produced by 24-month-old monolinguals in the original norms that cover the same range of frequencies, and (2) contain the same distribution of syntactic categories (nouns, verbs, pronouns, etc). We selected 10 words understood and produced by 100% of 2-year-old monolingual toddlers as provided by the Oxford CDI database, then 10 words understood and produced by 90% of the same children, etc. Then we adjusted these words to include a proportion of nouns, verbs and function words similar to those found in the Oxford CDI (see appendix 5 for the full list). To verify the validity of this Oxford Short Form CDI, the parents of 134 monolingual children from the Plymouth area (including 72 girls) aged 10 to 26 months (mean age 17.9 months) completed both the short and the long CDI within a week (mean number of days between completions: 4.3 days, SD 5.5). Their mean score on the long Oxford CDI was 160.2 words in comprehension (out of 416; SD 119.7) and 80.3 in production (SD 107.9); their mean score on the Oxford Short Form CDI was 43.5 words in comprehension (SD 28.0) and 23.0 in production (SD 28.2). Children's scores in the two CDIs were highly correlated in comprehension ($r = .95$, $p < .0001$) and in production ($r = .86$, $p < .0001$).

We also compared the scores directly for the 100 words that were present on both the long and the 100-word versions of the Oxford CDI: monolingual children's parents reported higher scores on the Oxford Short Form CDI, both for comprehension ($t$ (133) = 5.71, $p < .0001$, mean Oxford CDI score = 39.2%; mean Oxford Short Form CDI: 43.5%) and production ($t$ (133) = 5.40, $p < .0001$, mean Oxford CDI score = 20.4%; mean Oxford Short Form CDI: 23.0%). This difference is likely due to a fatigue or attentional effect when having to fill in a CDI four times as long as the 100 word Oxford Short Form CDI. Across the two completions, parents reported the same outcome (known or unknown) for 85.8% of words in comprehension, and 92.6% in production. Correlations between the short and long CDIs for the 100 words were $r = .95$ and $r = .98$ for comprehension and production respectively ($p < .0001$), indicating excellent validity for the Oxford Short Form CDI.

For the Additional Languages, we used the adaptations of CDIs for 12 Additional Languages with the authors' permission (see list in the appendix 1), selecting the form adapted for the age of 24 months when multiple versions were available. We developed a new CDI for Hindi/Urdu[3] (for simplicity we treated these two languages as dialects of the same language using different graphemic systems, so we developed the same version, written in the two alphabets). Additional Language CDIs had lengths varying from 654 words in Greek (Kati, personal communication) to 62 in Bengali (Hamadani et al., 2010; see appendix 1 for references of CDIs).

All parents were first asked to complete the Oxford Short Form CDI, assessing receptive and productive vocabulary separately. If they felt unable to do so because, for example, they never spoke English at home and therefore could not estimate their child's English knowledge, a proficient English speaking caregiver would complete the CDI (e.g. a childminder or an Early Years Practitioner). Parents were asked to complete the appropriate Additional Language CDI within a week of the completion of the Oxford Short Form CDI.

We ran 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, amongst 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 standardised

CDIs varied considerably in length for each language. While these data suffer from no ceiling effects and maximise the sampling of vocabulary, they are the least satisfactory in that there is no control of word frequency between all Additional Language CDIs, i.e. obtaining a 40% score in the German CDI is not necessarily equivalent to a 40% in the Portuguese CDI. The main analyses reported in the next chapter will be performed on the 30-word CDI, with a specific section added for the data from the full CDIs.

## Chapter 5 - Analyses and Results

We ran two-step analyses on the data from the 372 children whose Additional Language was one of our 13 target languages, with the aim of producing a predictive model for comprehension and production scores in their two languages (which is presented in Chapter 6).

In the first step, analyses were run 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 run initially in ANCOVAs (to include continuous variables such as LEQ) and then subjected to confirmation in linear mixed models (LMMs), with variables entered as fixed effects predictors only if they reached significance in the ANCOVAs.

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

LMMs have the advantage that Language Community (whether the child's Additional Language is Spanish, German, etc) can be modelled as a random effect thus allowing us to generalise our findings to bilinguals generally, rather than simply those whose Additional Language was one of the 13 test languages, an important objective for this study. However ANCOVAs allow a straightforward test of the significance of simultaneously entered predictor variables, something that is problematic with LMMs 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 whose significance was then confirmed in LMMs before being admitted to predictive models.

Following steps 1 and 2, predictive LMMs of expressive and receptive vocabulary for the UKBTAT tool were calculated with predictors retained only if their effect size in the ANCOVAs was larger than $\eta^2 = 0.02$ (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 which 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 amongst our 13 target Additional Languages. Predictive models for the UKBTAT are presented in Chapter 6.

**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), *quality of the input* (proportion of adult language mixing, 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.

INSERT TABLE 2 HERE

**Descriptive Statistics**

**Predictors.** Tables A6-2 to A6-4 in appendix 6 present 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 are reported in Table 3, and in Table 4 for each Additional Language. 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 (ALCDI30Comp and ALCDI30Prod), which was significantly less than in English (comprehension: paired $t$ (371) = 6.25, $p$ < .0001; production $t$ (371) = 11.51, $p$ < .0001)[4]. 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.

INSERT TABLE 3

INSERT TABLE 4

**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 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 (as aforementioned) the degree to which all other predictors are generalisable 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 appendix 7, tables A7-1 and A7-2 for full results).



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 hear, the more English they understand, and the less Additional Language they understand (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 ($F_{1,342}$ = 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).

INSERT FIGURE 1 HERE

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 marginally significant detrimental effect on Additional Language ($F_{1,342}$= 3.91, $p$ = .049, $\eta^2$ =.01) and a beneficial effect on English ($F_{1,342}$ = 143.30, $p < .001$, $\eta^2$ =.04) (see Figure 2). Income failed to reach significance ($F_{1,342}$ = 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).

INSERT FIGURE 2 HERE

LMMs 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 run for each fixed effect variable, with significance assessed by comparing each model against a null in which the fixed effect was absent. LMMs 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 appendix 7 (table A7-3 for comprehension and A7-4 for 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 ($\chi^2(2) = 23.59$, $p < .001$) and Gender ($\chi^2(1) = 13.26$, $p < .001$). When these analyses were re-run with each significant fixed effect entered into a model already containing the other significant fixed effects (table A7-5 in appendix 7), 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 generalises to all bilinguals, Income was discarded as a predictor for subsequent analyses. The remaining predictors at the end of Step 1 are the relative amount of exposure to English in child-directed speech (LEQ), the proportion of English in parental overheard speech (Overheard speech), and Gender.

**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 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), proportion of code switching (variable Mixing), presence of siblings (variable Siblings), and the 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: Mixing and PropEngN (see table A8-1 in appendix 8). Mixing 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 parental use of code switching ($F_{1,355}$= 6.07, $p$ = .014, $\eta^2$= .017). The proportion of parental native English spoken (PropEngN) significantly improved English production scores ($F_{1,296}$ = 4.12, $p$ = .043, $\eta^2$ = .01).

The effect of Mixing on English production scores was confirmed with a LMM ($\chi^2$(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 an LMM ($\chi^2$(1) < 1), and was not retained in the UKBTAT equations.

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 LMMs only (see tables A8-2 to A8-4 in appendix 8). These revealed a significant effect of 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 (Mixing and PropEngN) from Step 2 analyses were excluded at the ANCOVA stage, due to lack of significance. Mixing did have a significant effect in the subsequent LMM but its size effect was too small to warrant integration in the UKBTAT predictive models. PropEngN (proportion of English that is native) failed to reach significance in the LMM, and therefore will not be included in the UKBTAT models. All measures of Linguistic Distance, although significant in the LMMs, will not be included in the UKBTAT models because our aim was to build a predictive model for any bilingual child learning British English, 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 Additional Language CDIs). The pattern of significance was identical with effect sizes highly comparable. In particular, LMMs 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 paper, 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 organisation 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 to 30 months of age (Fenson et al., 2007), our dataset includes data for both English and Additional Language (when available) from 430 24-month-olds, collected using age-appropriate tools. One application of this 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.

# Chapter 6 - The UKBTAT Model

The UKBTAT (UK Bilingual Toddlers lAnguage Tool) is the first screening tool for assessing the vocabulary size of bilingual 2-year-olds learning British English and any Additional Language, regardless of which Additional Language is being learnt. Norms for bilingual vocabulary in English are obtained through equations from linear mixed models, using variables shown to be predictive of comprehension and production in the previous analyses. Similarly, norms for the Additional Language vocabulary are calculated if the child learns one of the 12 target Additional Languages[5].

## Characteristics of the UKBTAT

To be made freely accessible online at www.psy.plymouth.ac.uk/UKBTAT for early years practitioners and academics, the UKBTAT is similar to the platform used for data collection in this project, but with modifications suited to an applied setting. Firstly, access is secured for practitioners or academics through a personal account, allowing confidential storage of patient test results. Practitioners can use the system to send a link to parents requesting the completion of tests, and have full access to all responses if required. Alternatively tests can be printed and used offline with parents. The tests are still presented in the same order as in this study, with English 100-word Oxford Short Form CDI, full Additional Language CDI (when Additional Language is one of the supported target languages), finishing with the LEQ. The LEQ is still the last component that must be filled in by the practitioner, either on the phone or in a live interview with the parent(s). Many of the questions from the family questionnaire and the LEQ have been merged in an abbreviated LEQ, which retains only the questions relevant to the significant predictors (amount of exposure, gender, overheard speech).

In the UKBTAT all children are assessed in English, with those whose Additional Language is one of the 12 target languages also assessed in their Additional Language. This data is used to calculate a percentile score for the child's position in their cohort for expressive and receptive vocabulary. For children whose Additional Language is assessed, separate ratings will be provided for each language, otherwise only a single rating will be provided for English.

**UKBTAT Predictive Equations**

In order to be included in the UKBTAT model, predictors were required to reach significance in the ANCOVAs and the subsequent LMMs, and have an effect size of at least $\eta^2$ =.02 in the ANCOVAs (see Chapter 5). With these criteria, predictors that made it through Step 1 were the relative amount of English child-directed speech (LEQ), the proportion of English in parental overheard speech (Overheard speech) and Gender. No predictor relating to the source of each language, the quality of exposure and the status of the Additional Language survived Step 2 analyses. From the outset, we ruled out including Language Distance predictors in the equations since our aim was to provide models applicable to any Additional Language.

Coefficients were obtained from the final mixed models shown in appendix 8 (table A8-5). In the case of English, these were obtained from a model run on the full cohort of 430 children, and on the 100-word Oxford Short Form CDI data rather than the 30-word CDI, in order to improve representativeness for the UKBTAT implementation (as mentioned before, the 30-word CDI shows a ceiling effect for a third of children in English comprehension). For the Additional Languages, the coefficients were obtained from models run on the 372 children who provided Additional Language data, and on the 30-word CDIs. Altogether, these equations provide predicted scores for a bilingual of unspecified Additional Language in English, and in the Additional Language if it is part of our 12 target languages (Table 5).

INSERT TABLE 5 HERE

For example, an Italian-English girl (gender = 1) with 50% exposure to English (LEQ = 50) and parents speaking English and Italian equally often between themselves (Overheard speech = 3) should have a predicted English score of 64.7 in comprehension and 45.9 in production: she should understand 65 words from the Oxford Short Form CDI and produce 46. She should also obtain an Additional Language score of 18.83 in comprehension and 12.02 in production: she should understand 19 words in Italian from the 30-word CDI and produce 12.



As a diagnostic tool, it is important to be able to interpret the difference between a child's predicted and observed scores as a percentile. A reasonable threshold for suspecting a language delay is a score within the 10th percentile (Fenson et al., 2007; Rescorla, 2002; Tomblin, Records, & Zhang, 1996), so access to these ratings will allow practitioners to make an informed decision as to whether a referral might be necessary in a near future, or whether a wait and see approach is more appropriate.

We therefore examined the distribution of observed - predicted residuals in the mixed models from which the coefficients above were generated. Standard deviations of these residuals were as follows: English comprehension 21.19, English production 22.28, Additional Language comprehension 6.04, Additional Language production 7.60. These provide a basis for converting an observed - predicted difference scored in items into a percentile, which is what UKBTAT will report for a child screened by this tool. Thus in English comprehension, an observed - predicted decrement of 21.96 items places a child at exactly the 15th percentile, and a decrement of 27.16 items at exactly the tenth percentile. In the example above, if the Italian-English girl who was predicted an English comprehension score of 64.7 words scored in reality less than 42.7 (that is, 64.7-21.96), she would be in the 15th percentile (see Table 5).

Figure 3 provides the percentiles of word comprehension and production in English, illustrating the gender effect in production, and the difference between bilingual scores and monolingual data (see footnote 4).

INSERT FIGURE 3 HERE

It is worth pointing out that a common practice recommended by Rescorla (1989), known as the Delay 3 cutoff, is to refer for further assessment any (American English) monolingual 2-year-old child who produces fewer than 50 words from the LDS (which contains 310 words, therefore 16%), which identifies about 15% of children. Our findings clearly point to the infeasibility of this "one size fits all" approach for bilingual children: the English vocabulary production score that would be needed to be in the 15th percentile or below varies between 0 and 42.3 (out of 100), depending on the extreme values of the predictors. That is, a boy with the minimum exposure to English, and whose parents would always speak the Additional Language between them, should produce on average 14.0 words out of 100 on the English CDI, and a score of 0 would put him on the 15th percentile. In contrast, a girl hearing 100% English as measured by the LEQ and whose parents always speak English between them, should produce 65.6 on the English CDI, and a score of 42.3 would place her on the 15th percentile.



**Testing the Predictive Model**

We tested the validity of the equations above by seeing how accurately they could be used to predict novel data, namely those of the 58 non-target Additional Language children. Predicted scores for these children were generated using the equations (recalculated for the 372 children learning a target Additional Language) and then correlated with the observed scores. This was carried done for English scores only since non-target children had supplied no Additional Language data. For both comprehension and production, strong correlations were seen between predicted and observed scores (comprehension: r = .60; production: r = .59). Importantly, there was not any systematic under-prediction or over-prediction of scores in these novel data, as established by t-tests of the means of observed and predicted scores ($t < 1$).

This demonstrates that the model was not simply fitted to UKBT data a posteriori, but also has predictive validity. Furthermore, as the key test was of the validity of our norms was carried out with data from children outside of the range of Additional Languages used to develop the model, it shows that the model is predictive of *general* bilingual vocabulary, whatever Additional Language is spoken by the British-English learning bilingual. We therefore conclude that we have developed bilingual norms for 24-month-olds learning British English and any Additional Language, which have very clear cut-offs for referral once the proportion of English in child-directed input and parental overheard speech have been determined.

## Chapter 7 - General Discussion

Ours is the first study to directly measure the relative contribution of linguistic distance to the acquisition of a bilingual toddler's two languages. To address this question we tested 372 24-month-olds learning British English and one of 13 target Additional Languages. We found that a higher phonological overlap between these Additional Languages and British English led to higher levels of Additional Language CDI vocabulary production. Similar effects in comprehension were found for our other measures of linguistic distance, namely degree of similar in morphological complexity and word order. Importantly, linguistic distance contributed unique variance even when other key factors (proportion of English in child-directed input, proportion of English in parental overheard speech and gender) were entered into the same model.

Ours is also the first study to develop bilingual norms specified for the proportion of a particular language that a child hears in the input. To examine this question, we applied the model developed with the 372 24-month-olds learning British English and one of 13 target Additional Languages, to a cohort of 58 24-month-olds learning British English and an Additional Language which was not part of our 13 target languages. We found that the English vocabulary scores derived from the model were highly predictive of the vocabulary scores of these 58 children, showing a strong validity of our model for estimating word knowledge in any bilingual toddler growing up in the UK. This demonstrates the feasibility of assessing bilingual toddlers in the majority language only, providing SLTs and Early Years Professionals with a practical solution to a long-standing problem in societies where bilinguals come from heterogeneous backgrounds.

### Linguistic Distance and the Bilingual Lexicon

To explore the effect of linguistic distance on vocabulary outcome, we were faced with the problem of disentangling variance due to linguistic distance from that due to cultural diversity amongst language communities. In our initial analyses we treated our 13 target language pairs as a random factor. This provided an excellent fit between predicted and observed values from bilinguals learning an Additional Language outside of our 13 target languages, indicating that this factor should be included in any future study using heterogeneous sampling of bilinguals. In our second analysis we replaced the random effect of language with a linear predictor of linguistic distance, as measured by the phonological overlap between English words and their translation equivalents in the Additional Language. We found that children's production of Additional Language words was improved when this language was phonologically close to English (such as Dutch, Welsh, German) as compared to more distant languages (such as Cantonese, Polish and Greek). Testing other measures of linguistic distance, we found that children have a receptive vocabulary boost in their Additional Language if they learn a language with the same word order typology as British English (such as Polish or Portuguese) and/or a morphologically close language (such as Cantonese or Mandarin).

**Phonological overlap distance.** In the literature there is the tacit assumption that all bilinguals face the same challenges, irrespective of the language pairs being acquired (but see Argyri & Sorace, 2007). This is an assumption challenged by our finding that the linguistic distance between a bilingual child's languages shapes their word learning at the age of two. This finding is perhaps less surprising, given the recent growing evidence from monolingual research showing that young learners follow slightly different paths in speech perception (e.g. Mani & Plunkett, 2010; Nazzi, 2005), segmentation (e.g. Höhle et al., 2009) and lexical growth (e.g. Bleses et al., 2008) depending on the language they acquire. It is also supported by research examining adult bilingual lexical access which has investigated the effect of lexical overlap of translation equivalents on lexical access. Cognates, translation equivalents with form overlap, such as *bed* and *Bett* in German, are known to provide an advantage to production, similar to the linear measure of phonological overlap used in the current study. In word production, cognates are produced faster (e.g. Costa, Caramazza, & Sebastián-Gallés, 2000; Hoshino & Kroll, 2008), elicit a different brain signature (e.g. Strijkers, Costa, & Thierry, 2009), and produce higher levels of activation in priming tasks (e.g. Colomé & Miozzo, 2010) than non-cognates. The cognate advantage in picture naming is also found in young proficient bilinguals as early as 4 years (Sheng, Lam, Cruz, & Fulton, 2016; see also Poarch & van Hell, 2012).

To explain this advantage it has been proposed that cognates have different representations than non-cognates in the lexicon, perhaps because of a larger conceptual overlap (van Hell & De Groot, 1998), a shared morphological representation (Sánchez-Casas & García-Albea, 2005), or because they might have been learned earlier (Costa, Pannunzi, Deco, & Pickering, 2016). Alternatively, it has been proposed that the cognate advantage is the by-product of the dynamic interactions between the lexical and the phonological (and orthographical) levels of processing within the lexicon (Costa, Sanesteban, & Caño, 2005). Altogether, these findings with cognates show good equivalence with our own findings, where phonological overlap between translation equivalents increased Additional Language expressive vocabulary. This finding also provides support to the proposal that the cognate advantage is due to cognates being acquired before non-cognates in early childhood (Costa et al., 2016), leading to an ease of processing later in life.



Finally, the cognate advantage is an emerging property of recent computational models of the bilingual lexicon (BLINCS: Shook & Marian, 2013; DEV-LEX II: Zhao & Li, 2010): the activation of a concept in a common semantic lexicon during word production would generate parallel top-down activation of phonological representations from lexical representations in both L1 and L2. Any segments that overlapped between L1 and L2 representations would receive top-down activation from both of the languages lexical representations. This would provide an advantage to cognate or more overlapped translation equivalents, as they would become activated faster than those with less or non-overlapped representations (see also Costa et al., 2005).

One aspect of our results worth noting is that, although we found an increase in Additional Language vocabulary with phonological overlap in production, we found no effect in comprehension. This disparity also has some parallels in prior literature, where the evidence for a cognate advantage in bilingual spoken word recognition is mixed (see a review in Lagrou, Hartsuiker, & Duyck, 2011; see the review by Sánchez-Casas & García-Albea, 2005, for the cognate effect in *visual* word recognition). Although there is evidence for non-selective lexical access in word recognition as is found in production (Lagrou et al., 2011), that is, for online activation of words in both language, Shook, Goldrick, Engstler and Marian (2015) did not find any cognate advantage in a word recognition task in spoken English sentences in German-English bilinguals. When using an eye-tracking word recognition task for sets of pictures, Blumenfeld and Marian (2007) reported a cognate advantage dependent on the listener's proficiency in the target language. That is, whereas a cognate and non-cognate equally activate words in a highly proficient language, only cognates boost the activation of words in a less proficient language. In development all prior studies of cognate advantage in spoken word recognition have been with Spanish-English bilinguals. Again, findings are mixed, with some studies not finding any advantage in receptive vocabulary recognition (in first graders: Umbel, Pearson, Fernandez, & Oller, 1992; first to sixth graders: Umbel & Oller, 1994), while others did find an advantage (fifth and sixth graders: Cunningham & Graham, 2000; 8 to 13 years old: Kelley & Kohnert, 2012; kindergarten and first graders: Pérez, Peña, & Bedore, 2010). Kelley and Kohnert (2012) actually directly compared the cognate effect in production and comprehension using standardised tests, and found a very small advantage in comprehension, and a small to medium effect in production.

In comprehension a large proportion of the variance in the cognate advantage was due to age, with older children showing a greater advantage than younger ones.

In sum, our findings are the first to demonstrate that phonological overlap at the lexical level appears to boost the acquisition of expressive vocabulary in bilingual toddlers, which fits nicely with past demonstrations of a cognate advantage in older children and adults.

**Syntactic and morphological distance.** Our findings of a facilitatory effect of word order typology distance on receptive vocabulary can be explained in three, non-exclusive ways. First, children learning two languages with the same word order, such as British English and Polish, can probably use similar phrase-level prosodic cues for segmentation of syntactic constituents: indeed VO languages primarily use duration to express prosodic prominence of a content word as compared to a functor, while OV languages tend to use pitch/intensity (Nespor et al., 2008). The search for similar cues in the speech signal would lead to a single mechanism for prosodic-driven segmentation, boosting the retrieval of words and the assignment of syntactic categories. An additional explanation of this facilitatory effect is that, instead of activating both languages, bilinguals transfer the structure of their native language processing to that of the new language (Costa et al., 2016). Although this proposal applies to lexical processing in sequential bilinguals, the idea that a processing structure for one language can be 'carried over' to the other language also has currency for word order computation. Finally, some studies have proposed that word order variations amongst the world's languages are constrained by computational or learnability limitations, leading to a proliferation of easy-to-learn orders (e.g. Ferrer-i-Cancho, 2015; Lupyan & Christiansen, 2002). In this perspective, pairs of languages that differ on the word order dimension will add to the learnability issue by adding computational complexity.

In addition to word order typology we also found a facilitative effect of morphological similarity, with children learning Additional Languages morphologically close to English, such as isolating Cantonese or Mandarin, having better Additional Language comprehension vocabulary than those with a distant Additional Language, such as the agglutinative Bengali. In monolingual research, it has been argued that complex morphological systems may hinder language acquisition (e.g. Slobin, 1973) - although complex systems can be learnt quickly provided that morphological rules are regular and obligatory (e.g. Devescovi et al., 2005; Kim, McGregor, & Thompson, 2000). Our findings suggest that bilinguals learning languages with similar morphology may benefit from the training of cognitive resources engaged in supporting the learning of one kind of morphology over another, for example, memory for isolating languages, versus rule-based learning for synthetic languages, as suggested by Fortescue and Lennert Olsen (1992).

On a final note, when considering these findings it should be noted that language distance was found to modulate Additional Language scores only, with English scores being more resistant to facilitatory effects from the Additional Language proximity. We interpret this as showing that English acquisition benefits from the overarching effect of the English-speaking environment, whereas the Additional Language acquisition relies, in most cases, solely on one or two parents' input. While measures of exposure do not quantify the weight of everyday social interactions (shopping, visit to the doctor, media exposure, etc), a telling outcome that can be derived from Figure 1 is that in order for a bilingual child from our corpus to know an equal proportion of words in English and Additional Language, her/his exposure to English as measured by the LEQ only needs to be at 30% of English in comprehension (they would then know 23 out the 30 common words in English and the Additional Language) and 20% in production (they would then produce 14 out of the 30 common words in English and the Additional Language). These low English exposure values clearly fail to capture the overwhelming influence of the language of the surrounding community, and point to the relative vulnerability of the growth of L2.

In this study we have focussed on three measures of linguistic distance, phonological overlap of the child lexicon, syntax typology and morphological complexity, that reflect the core aspects of language development in the second year of life. However, ‘linguistic distance’ is fundamentally complex, with a multidimensional representation that goes beyond the factors examined thus far. Our database provides an opportunity to continue the exploration of how additional measures of linguistic distance can account for variations in bilingual vocabulary, for example, through examination of the effect of prosody on early word development (e.g. rhythmic families, final word lengthening, etc; White et al., in prep), or the effect of cross-linguistic differences in infant-directed speech styles (e.g. Fernald et al., 1989).

**Predicting Vocabulary Scores in Bilingual Toddlers**

The second key aim of the current study was to develop a model of English vocabulary which could be generalised to any bilingual learning British English and any Additional Language. To this aim we investigated which predictors should be included in this model. As expected, the most robust predictor of English and Additional Language vocabulary was found to be the relative amount of exposure to child-directed English vs the Additional Language (e.g. Hoff, 2003). This was predictive of both comprehension and production, with greater exposure to English increasing vocabularies in English, and reducing them in the Additional Language. Similarly, the proportion of English/Additional Language spoken *between* parents was also strongly predictive of comprehension and production in English, in line with previous studies showing that children encode information from overheard speech (Akhtar, 2005; Shneidman, Arroyo, Levine, & Goldin-Meadow, 2013).

SES effects were absent in our data, in keeping with prior studies which also had much reduced sampling at the low end of the SES spectrum (Fenson et al., 2007; Hamilton et al., 2000). The effects of these missing low SES children on the accuracy of UKBTAT norms are unclear. If they had been fully represented then we might have expected reduced vocabulary scores for low SES children, meaning that the current UKBTAT model would over-refer low SES children, and under-refer high SES children. There are a number of dangers with this assumption however, beyond those inherent in assuming that SES would have reached significance if provided with a fully balanced spectrum of samples. Fernald et al. (2013) reported that their SES effect, one of the strongest found in the literature, was stronger at the lower end of the SES spectrum. We confirmed this with a re-analysis of data points retrieved from Fernald et al's published scatterplot using the application Plot Digitizer (www.plotdigitizer.sourceforge.net), reproducing the originally reported correlation of .34. We then went on to split this data at median SES and analyse high and low SES data separately, finding that the correlation of SES with CDI comprehension was significant in low SES children (r = .42, $p$ = .001), but not in high SES children (r = .27, $p$ > .05). The nonlinearity of this effect means that it would be poorly modelled by linear equations, such as those used in the UKBTAT.

One of the other objectives of this study was to explore the predictive value of factors related to the source, quality, and status of the mode of exposure to English and the Additional Language. Only two predictors survived our analytical process - yet with small size effects that prevented their inclusion in the final predictive models: the proportion of native English spoken to the child, and the proportion of code switching.

It has already been shown that native speakers provide more supportive linguistic input than than non-natives (Hammer et al., 2012; Place & Hoff, 2011, 2016; although see Paradis, 2011, who found no effect). Therefore, our own finding that English production was found to increase with the proportion of native English parental input is in line with the general literature. It has been hypothesised that this could be due to non-native speech hindering the development of phonological categories (Fernald, 2006) and/or to non-native speakers using less varied vocabulary (Hoff et al., 2013).

Previous studies have reported either no effect (Place & Hoff, 2016) or a negative effect of code switching on vocabulary learning (Byers-Heinlein, 2013). In contrast our study found a positive effect, with parental switching improving English production. Our original argument was that the discrepancy between the two prior studies was due to language distance, as Byers-Heinlein tested mainly distant languages learners whilst Place and Hoff examined close languages learners. To examine whether the positive effect found here was different for close and distant language learners, we ran separate post-hoc regression analyses on the median split of children learning close (N = 240) and distant (N = 132) languages. For distant language learners, the amount of language mixing did not predict comprehension nor production, once corrected for exposure to English and the proportion of English in overheard speech. However, for children learning close languages, the amount of parental language mixing contributed significantly to improve English production scores (main model: $F$ (4, 239) = 11.34, $p < .001$; standardised $\beta$ for language mixing = 0.15, $p = .016$; no effect for comprehension, or for Additional Language scores). These results do provide some preliminary support for our original hypothesis: distant language learners are either impaired by code switching (Byers-Heinlein, 2013) or show no effect (this study), while close language learners either benefit from code switching (this study) or show no effect (Place & Hoff, 2016).

It is also worth highlighting that the status of the Additional Language had no effect on vocabulary knowledge of either English or the Additional Language: Welsh-English toddlers in Wales did not have significantly higher vocabulary scores than the other bilinguals, whether these scores were corrected by situational factors or not. In the literature, Welsh-English bilinguals' vocabulary in English tends to be lower than English monolinguals'

(Rhys & Thomas, 2013) at the ages of 7 and 11 years, with a strong effect of language dominance (as defined by exposure and family language) and a complex relation between home language exposure, SES, and age (Gathercole, et al., 2016). Our study shows that this “bilingual difference”, previously found in Welsh, is similar to that of any other bilingual minority group in the UK, at least at the age of 24 months. This point contributes to strengthen the generality of the UKBTAT model for predicting language outcomes in any incoming bilingual toddler growing in the UK.

**Application of the UKBTAT with Bilingual Children with Non-Target Additional Languages**

We created the UKBTAT norms for assessing the vocabulary of any bilingual 24-month-old learning British English and an Additional Language, regardless of which Additional Language it would be. These norms are available in British English, and in the Additional Language when this is part of our target languages. The recommendations of Speech and Language Therapists’ professional bodies are that bilinguals should be assessed in both their languages as there is a, quite justified, risk that an individual child’s situational factors may render an assessment performed on only one language unrepresentative of their overall linguistic capability. Unfortunately, for pragmatic reasons due to the heterogeneity of additional languages spoken in the UK, this recommendation can only be followed in a relatively small minority of cases, with bilinguals generally only assessed in English. Therefore, in this project we have sought to identify the situational factors that affect bilingual acquisition and quantify their contribution to improve the quality of English only testing. We have shown that only LEQ (relative amount of English exposure in child-directed input) and Overheard speech interacted with test language in the determination of vocabulary scores, thus we have no evidence that situational factors beyond these apply differently to the two test languages. This means there is no reason to suppose that Additional Language scores provide useful information beyond that of an English score, once corrected for these factors. Therefore, for clinical purposes, information provided by English vocabulary scores alone appears to provide an effective proxy for overall linguistic attainment, and can be safely used as normative data for any new incoming bilingual toddler. It is our hope that this pragmatic approach to bilingual screening will be generalised to other countries who are, like the UK, facing a growing number of bilingual infants from an increasingly heterogeneous background of languages.

**Conclusion**

The current study included two key strands of research questions. The first aimed to clarify our theoretical understanding of the factors which influence vocabulary development in bilingual toddlers. We found not only that the amount of exposure to each language in child-directed and overheard speech and infant gender are predictors of bilingual vocabulary development, but also moved the field forward by finding that linguistic distance between the two languages plays a role. Importantly, we also found that there was no effect for the societal status of the Additional Language being learned. This implies that our findings can be generalised both to bilingual toddlers learning a minority language, and also to those learning two languages which have more equivalent societal status, such as perhaps English and French in Canada.

Our second key research strand had an applied orientation as we addressed the feasibility of assessing a bilingual toddler's vocabulary in the majority language only, in order to provide Early Years Professionals, Health Visitors and SLTs with a practical solution when encountering bilingual children from heterogeneous backgrounds. The validity of this approach was successfully demonstrated when the UKBTAT model was applied to a new cohort of bilinguals learning a different Additional Language to our original target languages. In addition, the features of the UKBTAT (online, based on parental report and interview) are particularly appealing for an initial screening at such an early age where language assessments are notoriously challenging, and yet very desirable to plan appropriate intervention. It is our hope that the UKBTAT will enhance the early detection of children at risk of language delays in the growing UK bilingual population, and perhaps in other countries where the same approach could be applied.

## Appendix 1 - Additional Language CDIs References

**Bengali**

Hamadani, J. D., Baker-Henningham, H., Tofail, F., Mehrin, F., Huda, S. N., & Grantham-McGregor, S.M. (2010).Validity and reliability of mothers' reports of language development in 1-year-old children in a large-scale survey in Bangladesh. *Food and Nutrition Bulletin, 31*(2), S198-S206.

**Cantonese (Hong Kong) and Mandarin (Beijing)**

Tardiff, T., & Fletcher, P. (2008). Chinese Communicative Development Inventories: User's guide and manual, Peking University Medical Press, Beijing, China.

**Dutch**

Zink, I, & Lejaegere, M. (2002). N-CDIs: Lijsten voor Communicatieve Ontwikkeling. Aanpassing en hernormering van de MacArthur CDIs van Fenson et al. Acco, Leuven (Belgium) / Leusden(Netherlands). (A CDI user's manual with normative and validity data).

**French**

Kern, S., & Gayraud, G. (2010), Inventaire Français du Développement Communicatif (IFDC), Grenoble, La Cigale, 978-2-912457-91-2

**German**

FRAKIS: Szagun, G., Stumper, B., & Schramm, A.S. (2009). Fragebogen zur frühkindlichen Sprachentwicklung (FRAKIS) und FRAKIS-K (Kurzform). Frankfurt: Pearson Assessment. http://www.pearsonassessment.de

**Greek**

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**Italian**

Caselli, M.C., & Casadio, P. (1995). Il primo vocabolario del bambino: Guida all'uso del questionario MacArthur. Milan, Italy: Franco Angeli.

**Polish**

Smoczyńska, M. (1999). Inwentarz Rozwoju Mowy i Komunikacji: Słowa i Zdania [Polish Adaptation of The MacArthur-Bates Communicative Development Inventory: Words and Sentences]. Unpublished material. Krakow: Jagiellonian University.

**Portuguese**

Frota, S., Butler, J., Correia, S., Severino, C., Vicente, S., & Vigário, M. (2016). Infant communicative development assessed with the European Portuguese MacArthur-Bates Communicative Development Inventories Short forms. *First Language, 36*(5): 525-545. doi: 10.1177/0142723716648867

**Spanish**

López Ornat, S., Gallego, C., Gallo, P., Karousou, A., Mariscal, S., & Martínez, M. Evaluación de los niveles de lenguaje y comunicación de los niños pequeños. Inventario de desarrollo comunicativo de MacArthur. ISBN: 84-7174-820-7

**Welsh**

Mills, D., Gathercole, V., & Ebanks, N. (2013). The Bangor Welsh Communicative Development Inventory: Words and Gestures. Bangor University

**Appendix 2 - Calculation of UKBT Variables**

| | |
|---|---|
| Income | £0-£14,000 1<br>£14,001-£24,000 2<br>£24,001-£42,000 3<br>£42,001 or more 4 |
| Maternal education (MumEd) | No qualifications 1<br>Below standard for a pass on the school-leaving examination 2<br>O-levels (left school at 16) 3<br>A-levels (left school at 18) 4<br>Tertiary vocational qualifications 5<br>An undergraduate degree 6<br>A postgraduate degree 7 |
| Paternal education (DadEd) | As MumEd |
| Number of parental AL speakers (FamLang) | Value of 1 if only one parent is a native AL speaker, and 2 if both are. |
| Total number of speakers of English (SourcesEng) | A value from 0 upwards. Possible sources include a maximum of one BE speaking parent (scores 1), English DayCare (see below) (scores 1) and older children in the home (1 for each). Observed range for SourcesEng was 0-6. |
| Total number of speakers of the AL (SourcesAL) | A value from 1 upwards. Possible sources include a minimum of one and a maximum of two AL speaking parents (scores 1 each), AL daycare (see below) (scores 1) and older children in the home (1 for each). Observed range for SourcesAL was 1-7. |
| Time in English speaking daycare (EngDaycare) | Number of hours a week on average the child spends in an English speaking environment (nursery / day care / preschool / childminder / relative or friend) |
| Time in AL speaking daycare (ALDaycare) | Number of hours a week on average the child spends in an Additional Language environment (nursery / day care / preschool / childminder / relative or friend) |
| Number of older siblings (Siblings) | How many other children (24 months – 18 years) live in the home |

| | |
|---|---|
| Proportion of English/AL in overheard speech (Overheard speech) | When both parents are together with the child, and they talk between the two of them, which language do they speak?<br>1. Always AL, 2. Usually AL, 3. English about half the time, 4. Usually English, 5. Always English |
| Proportion of English/AL in maternal speech (MumPropEng) | Does the mother speak 1. Always AL, 2. Usually AL, 3. English about half the time, 4. Usually English, 5. Always English |
| Proportion of English/AL in paternal speech (DadPropEng) | As Mother |
| Proportion of language mixing in maternal speech (MumSwitch) | Derived from MumPropEng as follows: 1 or 5 = 1, 2 or 4 = 2, 3 = 3 |
| Proportion of language mixing in paternal speech (Dadswitch) | As Mumswitch |
| Proportion of language mixing in parental speech (Mixing) | Average of Mumswitch and Dadswitch |
| Proportion of native/non-native English (PropEngN) | This variable concerns input from parents only. The hours spent with each parent was computed as 168 – 7*Sleep – EngDaycare – ALDaycare – Hours alone with other parent (for 59 children this value was negative and PropEngN and PropALN could not be computed). Parents' score on PropEng variable (1 to 5) was re-expressed as a proportion from 0 to 1 (1 = 0, 2 = .25, 3 = .5, 4 = .75, 5 = 1).<br>This was multiplied by the hours the child spent with the parent to provide the hours of English input. If the parent was BE speaker this was native English input, if AL speaker this was non-native input. Both parents were assessed in this way. PropEngN was given by native English / (native + non-native Eng). |
| Proportion of native/non-native AL (PropALN) | As above, parents' score on PropEng was expressed as a proportion from 0 to 1 (1 = 0, 2 = .25, 3 = .5, 4 = .75, 5 = 1), with this value then subtracted from 1 to provide a proportion of time speaking AL. This was multiplied by the hours the child spent with the parent to provide the hours of AL input. If the parent was AL speaker this was native AL input, if BE speaker this was non-native AL input. Both parents were assessed in this way. PropALN was given by native AL / (native + non-native AL). |

## Appendix 3 - Details of the Calculation of Percentage of English Exposure in a Typical Week in the Year Preceding Testing (LEQ, adapted from Cattani et al., 2014)

### A. Input from the parents:

Number of hours a week in English-speaking nursery/childminder/playgroup = EngDaycare

Number of hours a week in an Additional Language speaking nursery/relatives = ALDaycare

Number of sleeping hours per night = Sleep

Does the mother always speak the Additional Language (AL) to the Child, or usually, or equally often English and the AL, or usually English, or always English (5 possible responses) = MumPropEng

Does the father always speak the AL to the Child, or usually, or equally often English and the AL, or usually English, or always English (5 possible responses) = DadPropEng

When together, who speaks most to the child? Mother, father or both = Most

Number of hours per week spent with mother only = HM

Number of hours per week spent with father only = HF

### B. Calculations

**1. Assign a percentage to M and F, to estimate the proportion of English in each parent's input to the child.**

If MumPropEng (or DadPropEng) = Always AL then ME (or FE) = 100

If MumPropEng (or DadPropEng) = Usually AL then ME (or FE) = 75

If MumPropEng (or DadPropEng) = Equally AL and English then ME (or FE) = 50

If MumPropEng (or DadPropEng) = usually English then ME (or FE) = 25

If MumPropEng (or DadPropEng) = always English then ME (or FE) = 0

**2. Correct HM and HF to give more weight to the time spent with the mother, as it is found usually that fathers tend to produce less verbal output to their child, therefore**

**directly impacting on the amount of exposure in English and the Additional Language (e.g. Pancsofar & Vernon-Feagans, 2006).**

Corrected time with mother = CHM = HM*4/3

Corrected time with father = CHF = HF*2/3

**3. Assign a value (MI to Most), to give more weight to the mother's input. What is obtained corresponds to the percentage of the mother's input during the time when both parents are with the child.**

If Most = Mother then MI = 90

If Most = Father then MI = 50

If Most = Both then MI = 70

**4. Calculate the number of hours per week with both parents together**

TBP = 7(24-Sleep) - EngDaycare - ALDaycare - CHM - CHF

**5. Calculate the total number of hours of English exposure in a week (E) with the following formula:**

E = English from mother when mother alone + English from father when father alone + English from mother when both parents together + English from father when both parents together + English from nursery or equivalent

$$E=\frac{\text{CHM}(100\text{-ME})}{100}+\frac{\text{CHF}(100\text{-FE})}{100}+\text{EngDaycare}+0.01*\text{TBP}*\frac{\text{MI}(100\text{-ME})}{100}+0.01*\frac{\text{TBP}(100\text{-MI})(100\text{-FE})}{100}$$

With English from mother when mother alone = CHM(100-ME)/100

English from father when father alone = CHF(100-FE)/100

English from mother when both parents together = 0.01*TBP*MI(100-ME)/100

English from father when both parents together = 0.01*TBP(100-MI)(100-FE)/100

**6. Calculate the percentage of exposure to English**

$$P = \frac{E}{7(24 - Sleep)}$$

## Appendix 4 - Breakdown of Languages for the Non-Target Additional Language Community

| | |
|---|---|
| Arabic | 6 |
| Bosnian | 1 |
| Bulgarian | 3 |
| Catalan | 1 |
| Czech | 3 |
| Danish | 3 |
| Finnish | 3 |
| French (Quebec) | 3 |
| Hebrew | 2 |
| Hungarian | 1 |
| Japanese | 5 |
| Kannada | 1 |
| Latvian | 1 |
| Lithuanian | 1 |
| Norwegian | 1 |
| Punjabi | 1 |
| Romanian | 2 |
| Russian | 1 |
| Serbian | 1 |
| Slovak | 8 |
| Swedish | 3 |
| Tagalog | 1 |
| Tamil | 1 |
| Turkish | 3 |
| Ukrainian | 1 |
| Yoruba | 1 |

*Table A4. Number of bilingual children per language group (N = 58); they all learn British English and one of 26 Additional Languages which are not part of our 13 target Additional Languages.*

## Appendix 5 - List and Results for Individual English Words in the Oxford Short Form CDI

| | **Nouns** | 35 | **door** | | **Others** |
|---|---|---|---|---|---|
| 1 | donkey | 36 | **table** | 70 | bye bye |
| 2 | **elephant** | 37 | bowl | 71 | cockadoodledoo |
| 3 | **fish** | 38 | broom | 72 | dinner |
| 4 | goose | 39 | brush | 73 | nap |
| 5 | kitten | 40 | **cup** | 74 | peekaboo |
| 6 | **lion** | 41 | glass | 75 | yes |
| 7 | penguin | 42 | key | 76 | **big** |
| 8 | pig | 43 | lamp | 77 | clean |
| 9 | squirrel | 44 | light | 78 | **cold** |
| 10 | **aeroplane / plane** | 45 | money | 79 | **dirty** |
| 11 | **car** | 46 | **scissors** | 80 | fast |
| 12 | **ball** | 47 | **soap** | 81 | happy |
| 13 | balloon | 48 | watch | 82 | **hot** |
| 14 | block / brick | 49 | **flower** | 83 | old |
| 15 | **book** | 50 | outside | 84 | soft |
| 16 | pen | 51 | **sky** | 85 | wet |
| 17 | butter | 52 | swing | 86 | **what** |
| 18 | cake | 53 | **tree** | 87 | **where** |
| 19 | cereal | 54 | wall | 88 | why |
| 20 | meat | 55 | aunt | 89 | now |
| 21 | **milk** | 56 | **mummy** | 90 | today |
| 22 | tea | | **Action words** | 91 | tomorrow |
| 23 | arm | 57 | call | 92 | back |
| 24 | mouth | 58 | carry | 93 | in |
| 25 | **nose** | 59 | catch | 94 | all |
| 26 | toe | 60 | drop | 95 | not |
| 27 | bib | 61 | **fall** | 96 | another |
| 28 | glasses / specs | 62 | finish | 97 | some |
| 29 | jacket | 63 | go | 98 | there |
| 30 | **shoe** | 64 | **play** | 99 | I |
| 31 | **sock** | 65 | splash | 100 | her |
| 32 | zip | 66 | swim | | |
| 33 | **bed** | 67 | tickle | | |
| 34 | **chair** | 68 | walk | | |
| | | 69 | want to | | |



*Table A5-1. List of words in the Oxford Short Form CDI and the 30-word CDI (in bold) in their order of presentation to parents.*

| | Production | | | | Comprehension | | | |
|---|---|---|---|---|---|---|---|---|
| LEQ (exposure) | 0-25% | >25-50% | >50-75% | >75-100% | 0-25% | >25-50% | >50-75% | >75-100% |
| | N=68 | N=105 | N=142 | N=57 | N=68 | N=105 | N=142 | N=57 |
| aeroplane/plane | 38.2 | 65.7 | 69.0 | 70.2 | 66.2 | 86.7 | 91.5 | 91.2 |
| ball | 69.1 | 84.8 | 92.3 | 93.0 | 86.8 | 99.0 | 99.3 | 100.0 |
| bed | 38.2 | 56.2 | 71.8 | 77.2 | 73.5 | 85.7 | 93.0 | 98.2 |
| big | 22.1 | 41.0 | 51.4 | 56.1 | 47.1 | 65.7 | 71.8 | 75.4 |
| book | 54.4 | 75.2 | 83.8 | 89.5 | 83.8 | 93.3 | 97.2 | 100.0 |
| car | 72.1 | 83.8 | 91.5 | 89.5 | 91.2 | 96.2 | 97.9 | 96.5 |
| chair | 27.9 | 50.5 | 65.5 | 71.9 | 63.2 | 85.7 | 93.0 | 94.7 |
| cold | 19.1 | 47.6 | 50.0 | 59.6 | 45.6 | 78.1 | 79.6 | 82.5 |
| cup | 29.4 | 47.6 | 58.5 | 63.2 | 60.3 | 80.0 | 89.4 | 91.2 |
| dirty | 20.6 | 41.9 | 49.3 | 64.9 | 47.1 | 77.1 | 83.8 | 84.2 |
| door | 32.4 | 61.9 | 76.8 | 84.2 | 73.5 | 87.6 | 95.1 | 96.5 |
| elephant | 44.1 | 49.5 | 61.3 | 59.6 | 83.8 | 85.7 | 89.4 | 93.0 |
| fall | 10.3 | 29.5 | 43.0 | 50.9 | 45.6 | 67.6 | 73.9 | 80.7 |
| fish | 64.7 | 72.4 | 80.3 | 78.9 | 85.3 | 90.5 | 95.8 | 94.7 |
| flower | 29.4 | 52.4 | 63.4 | 64.9 | 60.3 | 81.0 | 90.8 | 96.5 |
| hot | 42.6 | 66.7 | 74.6 | 84.2 | 69.1 | 89.5 | 90.8 | 94.7 |
| lion | 32.4 | 56.2 | 59.2 | 64.9 | 73.5 | 85.7 | 90.8 | 94.7 |
| milk | 44.1 | 66.7 | 70.4 | 78.9 | 75.0 | 91.4 | 93.0 | 94.7 |
| mummy | 94.1 | 95.2 | 92.3 | 96.5 | 97.1 | 98.1 | 97.9 | 100.0 |
| nose | 47.1 | 77.1 | 80.3 | 84.2 | 82.4 | 95.2 | 97.9 | 96.5 |
| play | 25.0 | 45.7 | 54.2 | 56.1 | 63.2 | 78.1 | 90.1 | 89.5 |
| scissors | 5.9 | 14.3 | 16.2 | 24.6 | 30.9 | 39.0 | 50.0 | 59.6 |
| shoes | 66.2 | 83.8 | 88.0 | 91.2 | 89.7 | 97.1 | 99.3 | 98.2 |
| sky | 13.2 | 35.2 | 40.8 | 45.6 | 30.9 | 64.8 | 66.9 | 75.4 |
| soap | 11.8 | 24.8 | 28.2 | 36.8 | 41.2 | 45.7 | 64.1 | 70.2 |
| sock | 51.5 | 74.3 | 81.0 | 80.7 | 76.5 | 91.4 | 96.5 | 98.2 |
| table | 20.6 | 38.1 | 50.0 | 52.6 | 60.3 | 82.9 | 90.1 | 93.0 |
| tree | 30.9 | 48.6 | 64.8 | 68.4 | 57.4 | 77.1 | 88.0 | 94.7 |
| what | 19.1 | 31.4 | 33.8 | 36.8 | 42.6 | 53.3 | 64.1 | 68.4 |
| where | 14.7 | 34.3 | 33.8 | 38.6 | 61.8 | 73.3 | 79.6 | 84.2 |
| Mean | 36.4 | 55.1 | 62.5 | 67.1 | 65.5 | 80.8 | 86.7 | 89.6 |

*Table A5-2. For words from the 30-word CDI, proportion of bilingual children (all 13 target Additional Languages collapsed) who produce and understand each word in English. Children's data are binned as a function of exposure (as measured by the LEQ). For example, the word 'ball' is produced by 69.1% of those children exposed to English between 0 and 25% of the time, and by 93.0% of those children exposed to English between 75 and 100%.*

# Appendix 6 - Predictor Values per Language Community

| | Number of children | Number of children per gender | | Age in months | | Income bracket | | Maternal education (MumEd) | | Paternal education (DadEd) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | total | girls | boys | mean | std | mean | std | mean | std | mean | std |
| Bengali | 13 | 7 | 6 | 24.02 | 0.38 | 3.45 | 0.69 | 5.15 | 1.95 | 5.77 | 1.64 |
| Cantonese Chinese | 8 | 6 | 2 | 23.90 | 0.46 | 3.88 | 0.35 | 6.50 | 0.53 | 6.13 | 0.35 |
| Dutch | 14 | 6 | 8 | 23.96 | 0.42 | 3.71 | 0.47 | 6.43 | 0.65 | 6.00 | 1.24 |
| French | 55 | 28 | 27 | 23.96 | 0.34 | 3.74 | 0.48 | 6.69 | 0.60 | 6.24 | 1.09 |
| German | 75 | 31 | 44 | 23.87 | 0.38 | 3.60 | 0.62 | 6.36 | 1.01 | 6.21 | 1.18 |
| Greek | 12 | 6 | 6 | 23.85 | 0.37 | 3.67 | 0.89 | 6.75 | 0.62 | 6.33 | 1.15 |
| Hindi/Urdu | 9 | 2 | 7 | 23.99 | 0.30 | 3.67 | 0.50 | 6.44 | 1.01 | 6.78 | 0.44 |
| Italian | 33 | 13 | 20 | 23.84 | 0.36 | 3.70 | 0.47 | 6.55 | 0.56 | 5.97 | 1.24 |
| Mandarin Chinese | 8 | 6 | 2 | 24.09 | 0.48 | 3.25 | 1.16 | 6.63 | 0.52 | 6.00 | 1.41 |
| Polish | 29 | 17 | 12 | 23.92 | 0.43 | 3.26 | 0.71 | 6.38 | 1.01 | 5.38 | 1.50 |
| Portuguese | 10 | 4 | 6 | 23.93 | 0.34 | 3.33 | 0.87 | 6.30 | 0.67 | 6.10 | 0.99 |
| Spanish | 43 | 18 | 25 | 23.79 | 0.30 | 3.59 | 0.74 | 6.42 | 0.73 | 5.81 | 1.22 |
| Welsh | 63 | 20 | 43 | 23.95 | 0.44 | 3.61 | 0.71 | 6.05 | 1.07 | 5.70 | 1.27 |
| Other | 58 | 29 | 29 | 23.80 | 0.42 | 3.54 | 0.71 | 6.33 | 0.87 | 5.81 | 1.53 |
| **Grand total/mean** | **430** | **193** | **237** | **23.89** | **0.39** | **3.59** | **0.66** | **6.36** | **0.94** | **5.96** | **1.28** |

*Table A6-1. Demographic characteristics of participants per Additional Language community: gender, mean age in months (when completion of Oxford Short Form CDI), mean household income (4-point scale scale from 1 to 4), maternal and paternal education (7-point scale scale from 1 to 7). See appendix 2 for details of the calculations of Income, MumEd and DadEd.*

| | Number of families with one or both parents AL speakers | | Total number of English speakers | | Total number of AL speakers | | Number of hours per week in English speaking | | Number of hours per week in AL speaking | | Number or older siblings | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FamLang | | SourcesEng | | SourcesAL | | EngDaycare | | ALDaycare | | Siblings | |
| | AL only | Mixed | mean | std | mean | std | mean | std | mean | std | mean | std |
| Bengali | 11 | 2 | 3.31 | 1.18 | 3.31 | 1.55 | 8.31 | 10.04 | 7.50 | 8.34 | 0.92 | 1.32 |
| Cantonese Chinese | 3 | 5 | 2.75 | 0.46 | 2.38 | 0.74 | 25.75 | 14.41 | 15.81 | 16.33 | 0.00 | 0.00 |
| Dutch | 3 | 11 | 2.64 | 1.22 | 2.29 | 0.83 | 18.68 | 14.38 | 9.39 | 19.56 | 0.43 | 0.65 |
| French | 4 | 51 | 2.80 | 0.89 | 2.31 | 1.10 | 24.93 | 14.74 | 4.30 | 11.09 | 0.44 | 0.71 |
| German | 10 | 65 | 2.84 | 1.10 | 2.27 | 0.98 | 16.56 | 13.32 | 5.33 | 12.46 | 0.59 | 0.77 |
| Greek | 3 | 9 | 2.42 | 1.38 | 2.50 | 1.00 | 23.46 | 17.28 | 9.54 | 19.00 | 0.50 | 0.90 |
| Hindi/Urdu | 7 | 2 | 3.33 | 1.32 | 3.00 | 1.22 | 9.89 | 11.34 | 1.67 | 3.94 | 0.89 | 1.17 |
| Italian | 14 | 19 | 2.52 | 0.94 | 2.45 | 1.06 | 21.95 | 15.39 | 2.76 | 5.56 | 0.36 | 0.55 |
| Mandarin Chinese | 3 | 5 | 2.75 | 0.89 | 2.00 | 0.53 | 24.06 | 14.86 | 4.00 | 9.75 | 0.13 | 0.35 |
| Polish | 7 | 22 | 2.48 | 0.78 | 2.17 | 1.00 | 18.33 | 13.42 | 3.74 | 8.62 | 0.28 | 0.53 |
| Portuguese | 5 | 5 | 2.20 | 0.79 | 2.30 | 0.82 | 29.45 | 18.21 | 6.95 | 15.52 | 0.20 | 0.42 |
| Spanish | 14 | 29 | 2.23 | 0.72 | 2.23 | 0.90 | 21.47 | 16.98 | 3.92 | 8.39 | 0.23 | 0.43 |
| Welsh | 26 | 37 | 2.51 | 1.09 | 2.63 | 1.11 | 14.44 | 14.61 | 8.70 | 11.36 | 0.46 | 0.78 |
| Other | 20 | 38 | 2.55 | 1.13 | 2.09 | 0.90 | 18.03 | 15.38 | 1.68 | 5.28 | 0.36 | 0.58 |
| **Grand Total/mean** | **130** | **300** | **2.63** | **1.03** | **2.36** | **1.03** | **19.03** | **15.19** | **5.20** | **10.99** | **0.43** | **0.71** |

*Table A6-2. Characteristics of participants per Additional Language community in terms of mode of exposure (sources). Number of families where both parents are Additional Language speakers (Additional Language only) or only one (Mixed) (variable FamlLang); Total number of regular English (or Additional Language) speakers around the child (SourcesEng and SourcesAL; observed range 0-6); weekly number of hours in an English (or Additional Language) speaking daycare (EngDaycare and ALDaycare); number of older siblings in the household (Siblings). See appendix 2 for details of the calculations of these variables.*

| | Proportion of language mixing in parents' input | | Proportion of native English in parents' input | | Proportion of native AL in parents' input | |
|---|---|---|---|---|---|---|
| | Mixing | | PropEngN | | PropALN | |
| | mean | std | mean | std | mean | std |
| Bengali | 2.08 | 0.64 | 0.031 | 0.19 | 1.000 | 0.00 |
| Cantonese Chinese | 1.94 | 0.68 | 0.450 | 0.41 | 0.969 | 0.09 |
| Dutch | 1.43 | 0.43 | 0.708 | 0.38 | 0.918 | 0.15 |
| French | 1.47 | 0.39 | 0.695 | 0.55 | 0.932 | 0.15 |
| German | 1.37 | 0.40 | 0.737 | 0.35 | 0.972 | 0.08 |
| Greek | 1.29 | 0.50 | 0.836 | 0.32 | 0.958 | 0.10 |
| Hindi/Urdu | 2.06 | 0.77 | 0.114 | 0.25 | 0.936 | 0.15 |
| Italian | 1.44 | 0.46 | 0.572 | 0.44 | 0.958 | 0.14 |
| Mandarin Chinese | 1.63 | 0.35 | 0.524 | 0.37 | 0.978 | 0.06 |
| Polish | 1.43 | 0.44 | 0.735 | 0.38 | 0.932 | 0.15 |
| Portuguese | 1.55 | 0.64 | 0.393 | 0.57 | 0.982 | 0.06 |
| Spanish | 1.42 | 0.56 | 0.697 | 0.42 | 0.905 | 0.24 |
| Welsh | 1.50 | 0.52 | 0.575 | 0.43 | 0.933 | 0.18 |
| Other | 1.47 | 0.49 | 0.761 | 0.98 | 0.967 | 0.10 |
| **Mean** | **1.48** | **0.50** | **0.649** | **0.55** | **0.948** | **0.14** |

*Table A6-3. Characteristics of participants per Additional Language community in terms of mode of exposure (quality). Amount of language mixing in parents' speech (Mixing; 3-point scale from 1 to 3); proportion of native vs non-native English input in parental speech (PropEngN); proportion of native vs non-native Additional Language input in parental speech (PropALN). See appendix 2 for details on the calculation of these variables.*

| | Proportion of English vs. AL in child directed speech | | Proportion of English in mother input | | Proportion of English in father input | | Proportion of English vs. AL between parents | |
|---|---|---|---|---|---|---|---|---|
| | LEQ | | MumPropEng | | DadPropEng | | Overheard speech | |
| | mean | std | mean | std | mean | std | mean | std |
| Bengali | 49.80 | 26.44 | 3.00 | 1.22 | 3.15 | 1.34 | 3.46 | 1.56 |
| Cantonese Chinese | 61.77 | 21.74 | 3.13 | 1.25 | 4.00 | 1.07 | 4.25 | 1.16 |
| Dutch | 47.01 | 25.44 | 2.14 | 1.35 | 3.57 | 1.74 | 4.36 | 1.28 |
| French | 56.02 | 22.37 | 2.25 | 1.40 | 3.67 | 1.55 | 4.36 | 1.08 |
| German | 46.27 | 21.64 | 1.96 | 1.21 | 4.07 | 1.48 | 4.33 | 1.33 |
| Greek | 46.53 | 25.91 | 2.08 | 1.62 | 3.17 | 1.85 | 3.58 | 1.83 |
| Hindi/Urdu | 52.14 | 29.77 | 2.89 | 1.36 | 2.78 | 1.20 | 2.56 | 1.59 |
| Italian | 48.04 | 25.08 | 2.06 | 1.37 | 2.88 | 1.71 | 3.24 | 1.77 |
| Mandarin Chinese | 48.06 | 15.05 | 1.88 | 0.64 | 3.63 | 1.69 | 3.50 | 1.85 |
| Polish | 45.25 | 22.50 | 1.86 | 1.06 | 3.55 | 1.72 | 4.00 | 1.67 |
| Portuguese | 57.14 | 24.81 | 2.40 | 1.35 | 2.50 | 1.84 | 2.70 | 1.89 |
| Spanish | 45.88 | 22.88 | 2.00 | 1.35 | 2.98 | 1.77 | 3.40 | 1.80 |
| Welsh | 46.79 | 28.02 | 2.35 | 1.48 | 3.22 | 1.67 | 4.03 | 1.47 |
| Other | 51.26 | 24.65 | 2.10 | 1.27 | 3.55 | 1.67 | 3.71 | 1.73 |
| **Mean** | **49.13** | **24.14** | **2.17** | **1.33** | **3.45** | **1.65** | **3.87** | **1.59** |

*Table A6-4. Mean amount of exposure to English versus Additional Language in child directed speech for each Additional Language group (LEQ); proportion of English vs the Additional Language in maternal (or paternal) speech on a 5-point scale from 1 to 5 (MumPropEng and DadPropEng); proportion of English vs the Additional Language spoken between parents in overheard speech (Overheard speech; 5-point scale from 1 to 5; 1 = only Additional Language to 5 = only English). See appendix 3 for details of LEQ calculation, and Appendix 2 for details of calculation of the other variables.*

## Appendix 7 - Step 1 Analyses

| | Sum of squares | df | *F* | *p* | $\eta^2$ |
|---|---|---|---|---|---|
| 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 |

*Table A7-1. ANCOVA results for* ***comprehension*** *on the 30-word CDIs (English: CDI30Comp; Additional Language: ALCDI30Comp), in* ***Step 1 analyses*** *(predictors firmly established in the literature). TestLang = English vs Additional Language. All variables are z-scored. N = 359 as income data was not provided for 13 children out of 372.*

| | Sum of squares | df | *F* | *p* | $\eta^2$ |
|---|---|---|---|---|---|
| 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 |

*Table A7-2. ANCOVA results for* ***production*** *on the 30-word CDIs (English: CDI30Prod; Additional Language: ALCDI30Prod), in* ***Step 1 analyses*** *(predictors firmly established in the literature). TestLang = English vs Additional Language. All variables are z-scored. N = 359 as income data was not provided for 13 children out of 372.*

| Fixed effect | | Coef. | Std. Error | *t* | $X^2$ | *p* |
|---|---|---|---|---|---|---|
| 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 |

*Table A7-3. Coefficient estimates from the LMMs 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). For each variable which survived the ANCOVAs, e.g. LEQ, tests of significance ($X^2$) to compare the full model and its null are provided in the last two columns. TestLang = English vs 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.*

| Fixed effect | | Coef. | Std. Error | *t* | $X^2$ | *p* |
|---|---|---|---|---|---|---|
| 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 |

*Table A7-4. Coefficient estimates from the LMMs 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). For each variable which survived the ANCOVAs, e.g. LEQ, tests of significance ($X^2$) to compare the full model and its null are provided in the last two columns. TestLang = English vs Additional Language. N = 372. All variables were z-scored.*

| | | Coef. | Std. Error | *t* | $\chi^2$ | *p* |
|---|---|---|---|---|---|---|
| **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 |

*Table A7-5. Coefficient estimates from the LMMs used in **Step 1 analyses** after the ANCOVAs, to estimate the robustness of each predictor when incremented onto models containing the other ones. 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 LMMs with single predictors (tables A7-1 to 4), the coefficients for the full models are presented. Then for each variable of interest, e.g., LEQ, tests of significance ($\chi^2$) to compare the full model and its null are provided in the last two columns. TestLang = English vs Additional Language. N = 372. All variables were z-scored.*

## Appendix 8 - Step 2 Analyses and UKBTAT Models

| | Sum of squares | df | *F* | *p* | $\eta^2$ |
|---|---|---|---|---|---|
| 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*Mixing | 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 |
| Mixing | 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 |

*Table A8-1. ANCOVA results for* ***Step 2 analyses*** *(surviving predictors from Step 1 plus less well established predictors), restricted to those predictors providing significant effects. The dependent variables are scores in* ***production*** *on the 30-word CDIs (English: CDI30Prod; Additional Language: ALCDI30Prod). TestLang = English vs Additional Language. All variables were z-scored. The effect of Mixing (proportion of language mixing in parental speech, see Appendix 2) is calculated with N = 372. The effect of the proportion of native vs non –native 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).*

| | | Coef. | Std. Error | *t* | $X^2$ | *p* |
|---|---|---|---|---|---|---|
| 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 |

*Table A8-2. Coefficient estimates from the LMMs 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. 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.*

| | | Coef. | Std. Error | *t* | $X^2$ | *p* |
|---|---|---|---|---|---|---|
| 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 |

*Table A8-3. Coefficient estimates from the LMMs 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. 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.*

| | | Coef. | Std. Error | *t* | $X^2$ | *p* |
|---|---|---|---|---|---|---|
| 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 |

*Table A8-4. Coefficient estimates from the LMMs 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. 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.*

| | | Coef. | Std. Error | *t* |
|---|---|---|---|---|
| English comprehension | Intercept | 37.62 | 3.78 | 9.97 |
| | LEQ | 0.23 | 0.08 | 2.78 |
| | Overheard speech | 5.19 | 0.90 | 5.76 |
| Additional Language comprehension | Intercept | 21.83 | 1.87 | 11.70 |
| | LEQ | -0.06 | 0.02 | -3.09 |
| English production | Intercept | 34.48 | 5.76 | 5.99 |
| | LEQ | 0.24 | 0.09 | 2.68 |
| | Overheard speech | 3.85 | 1.14 | 3.39 |
| | Gender | -12.16 | 2.44 | -4.98 |
| Additional Language production | Intercept | 18.69 | 2.10 | 8.91 |
| | LEQ | -0.07 | 0.02 | -3.71 |
| | Gender | -3.17 | 0.83 | -3.80 |

*Table A8-5. Coefficient estimates from the LMMs* ***for the UKBTAT****, for comprehension and production, in each language (English and the Additional Language). Dependent variables are scores on the 100-word CDI in English (comprehension: CDI100comp; production: CDI100prod) and on the 30-word CDI in the Additional Language (comprehension: ALCDI30Comp; production: ALCDI30Prod). For English, the models were calculated with N = 430 children and with N = 372 for the Additional Language. Variables were not z-scored so that they could be directly applied to new raw scores.*

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# Acknowledgements

**Footnotes**

1. Following King (2001), spoken Hindi and Urdu were classified as two varieties of the same language.
2. At this stage, the wording in the various questionnaires follows the heterosexual family model.
3. Following the method by Kern (2007), after a translation of the Oxford CDI, two focus groups of native Urdu speakers agreed on a cultural adaptation of the word list. Native Hindi speakers were consulted to check its adaptation to Hindi.
4. Of interest is the comparison of the bilingual scores to monolinguals. Based on the Oxford CDI database for 125 monolingual children aged 23.0 to 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 0.90 provides an equivalent score on the short CDI. That means that the 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: $t\ (553) = 4.74$, $p = .0001$).
5. Spanish is sadly absent from the final list of target languages due to some disagreement with the Spanish CDI editors, TEA Ediciones.

| **Additional Language** | **Phonological Overlap** | **Word order typology** | **Morphological complexity** |
|---|---|---|---|
| Dutch | 0.2214 | 2 | 2 |
| Welsh | 0.2163 | 1 | 2 |
| German | 0.1975 | 2 | 2 |
| Italian | 0.1076 | 1 | 2 |
| French | 0.1034 | 1 | 2 |
| Bengali | 0.0941 | 3 | 3 |
| Hindi | 0.0899 | 3 | 3 |
| Spanish | 0.0874 | 1 | 2 |
| Polish | 0.0828 | 1 | 2 |
| Greek | 0.0807 | 1 | 2 |
| Portuguese | 0.0801 | 1 | 2 |
| Cantonese | 0.0422 | 1 | 1 |
| Mandarin | 0.0197 | 1 | 1 |

*Table 1. Average phonological overlap between 406 British English words of the Oxford CDI and their translation equivalents for the 13 Additional Languages. The higher the number, the closer the languages. Word order typology distance to British English (1 = VO language like British English; 2 = VO/OV language; 3 = OV language). Morphological complexity distance to British English (1 = analytic/isolating language like British English; 2 = fusional; 3 = agglutinative).*

| | Description | Codename | Measure |
|---|---|---|---|
| **Step 1 predictors and variables** | Gender | Gender | male/female |
| | Income (SES) | Income | 4-point scale |
| | Maternal education (SES) | MumStudy | 7-point scale |
| | Paternal education (SES) | DadStudy | 7-point scale |
| | Relative amount of exposure to English in child directed speech | LEQ | proportion |
| | Proportion of English/AL in overheard speech | Overheard speech | 5-point scale |
| | Language community | Language community | dummy variable from 1 to 13 (Spanish, etc) |
| | Which language is measured (within-subject) | TestLang | English vs AL |
| **Step 2 predictors** | Number of parental AL speakers (source) | FamLang | 1 or 2 |
| | Total number of English speakers (source) | SourcesEng | from 0 upwards |
| | Total number of AL speakers (source) | SourcesAL | from 0 upwards |
| | Number of older siblings (source) | SIB | from 0 upwards |
| | Time in English daycare (source) | EngDaycare | hours |
| | Time in AL daycare (source) | ALDaycare | hours |
| | Proportion of language mixing in parental speech (quality) | Mixing | 5-point scale |
| | Proportion of native/non-native in English input (quality) | PropEngN | proportion |
| | Proportion of native/non-native in AL input (quality) | PropALN | proportion |
| | Societal status of the AL (status) | Status | Welsh vs all other ALs |
| | Linguistic distance measured through phonological overlap | Overlap | from 0 upwards |
| | Linguistic distance measured through morphological complexity | Morph | 3-point scale |
| | Linguistic distance measured through word order typology | WordOrder | 3-point scale |
| **Dependent variables** | English comprehension on the Oxford Short Form CDI | CDI100comp | 0 to 100 |
| | English production on the Oxford Short Form CDI | CDI100prod | 0 to 100 |
| | English comprehension on the 30-word CDI | CDI30comp | 0 to 30 |
| | English production on the 30-word CDI | CDI30prod | 0 to 30 |
| | AL comprehension on the AL full CDI | PropALComp | proportion |
| | AL production on the AL full CDI | PropALProd | proportion |
| | AL comprehension on the 30-word CDI | ALCDI30comp | 0 to 30 |
| | AL production on the 30-word CDI | ALCDI30prod | 0 to 30 |

*Table 2. List of all variables and predictors used in the analyses. More details on calculations are provided in appendices 2 and 3 (for LEQ).*

| | 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 | std | Mean | std | Mean | std | Mean | std |
| 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** |

*Table 3. English vocabulary measures for each Additional Language group. 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).*

| | 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 | std | Mean | std | Mean | std | Mean | std | |
| 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** |

*Table 4. Additional Language vocabulary measures for each Additional Language group. 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.*

| | Coefficients | | | | Decrements | |
|---|---|---|---|---|---|---|
| | Intercept | LEQ | Overheard speech | Gender | 10th percentile decrement | 15th percentile decrement |
| **Comprehension** | | | | | | |
| Predicted English 100 score | 37.62 | 0.23 | 5.19 | | 27.16 | 21.96 |
| Predicted AL 30 score | 21.83 | -0.06 | | | 28.55 | 23.09 |
| **Production** | | | | | | |
| Predicted English 100 score | 34.48 | 0.24 | 3.85 | -12.16 | 7.74 | 6.26 |
| Predicted AL 30 score | 18.69 | -0.07 | | -3.17 | 9.74 | 7.88 |

*Table 5. Coefficients from the LMMs of vocabulary knowledge in English and the Additional Language, in comprehension and production, and decrements derived from standard deviations of residuals. For example, the predicted English score in comprehension is: 37.62 + 0.23 x LEQ + 5.19 x Overheard speech, with LEQ ranging from 0 to 100 (proportion of exposure to English vs the Additional Language in child directed speech), and Overheard speech ranging between 1 and 5 (1 = parents always speak the AL between them; 2 = parents usually speak the Additional Language between them; 3 = parents speak the Additional Language and English half of the time; 4 = parents usually speak English between them; 5 = parents always speak English between them). Gender is assigned a value of 1 for girls and 2 for boys. Decrement is then applied to the predicted score, and compared to the observed score to determine if the child's score is below the 10th or the 15th percentile.*

**Figure Captions**

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.

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).

Figure 3. Percentile values in English comprehension (left) and production (right) measured from the Oxford Short Form CDI, as function of gender, in the full cohort of bilingual toddlers (N=430). For comparative purposes, monolingual data for comprehension and production are included on the same graphs (N= 125, taken from the Oxford CDI database, Hamilton et al., 2000).

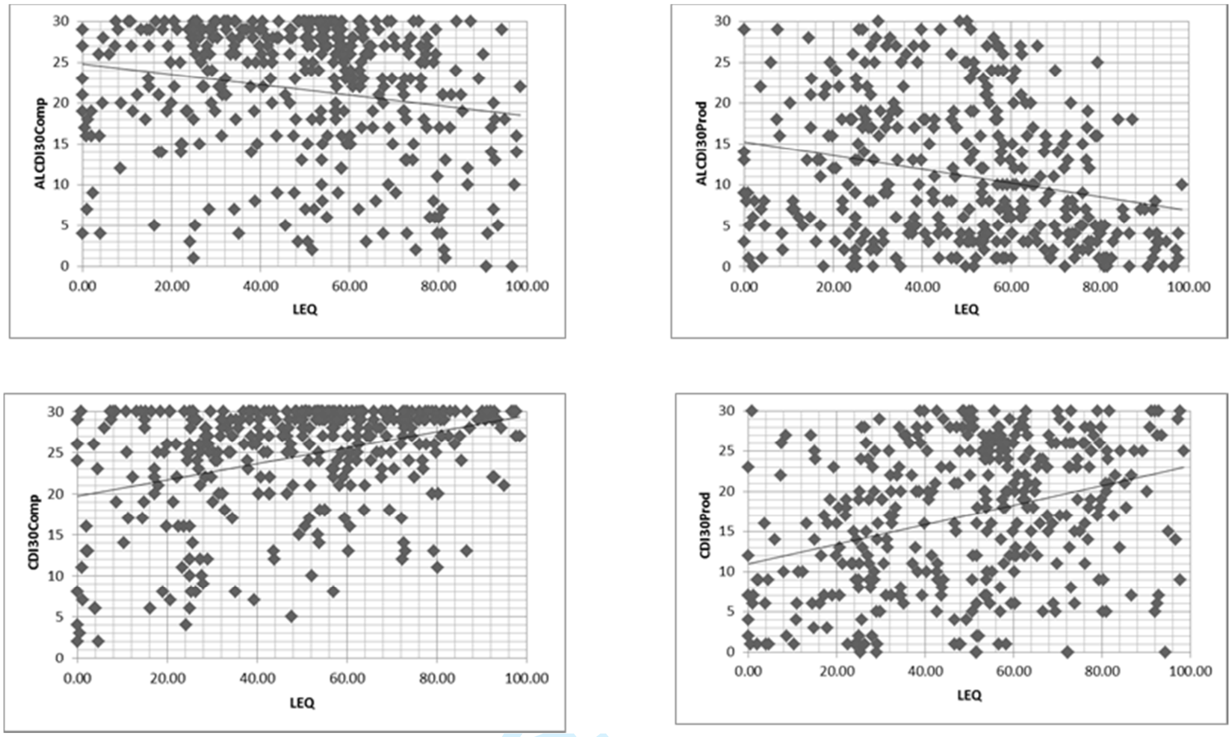

ALCDI30Comp
LEQ
ALCDI30Prod
LEQ
CDI30Comp
LEQ
CDI30Prod
LEQ
0 5 10 15 20 25 30
0.00 20.00 40.00 60.00 80.00 100.00



Figure 1

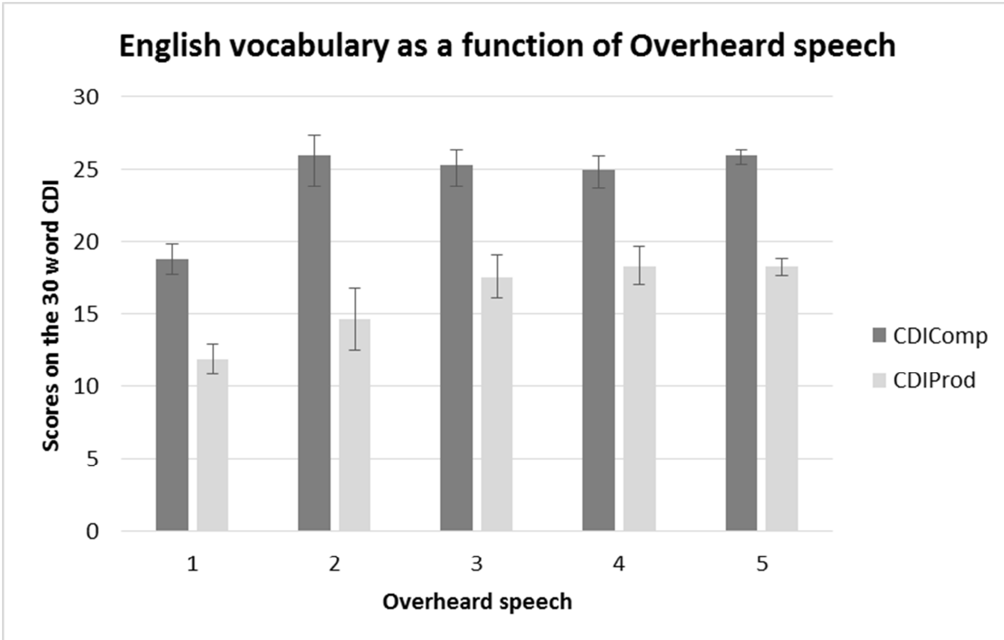
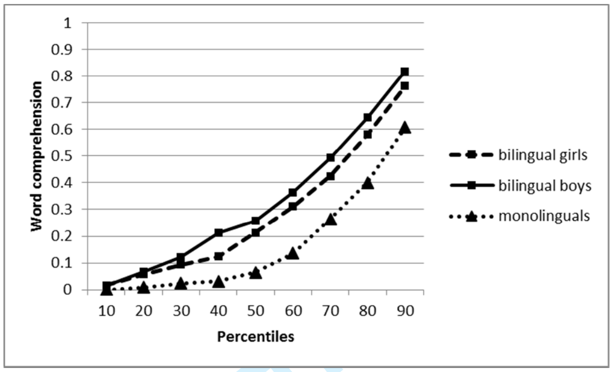

English vocabulary as a function of Overheard speech
Scores on the 30 word CDI
30
25
20
15
10
5
0
1
2
3
4
5
Overheard speech
CDIComp
CDIProd

Figure 2


Word comprehension
Percentiles
bilingual girls
bilingual boys
monolinguals

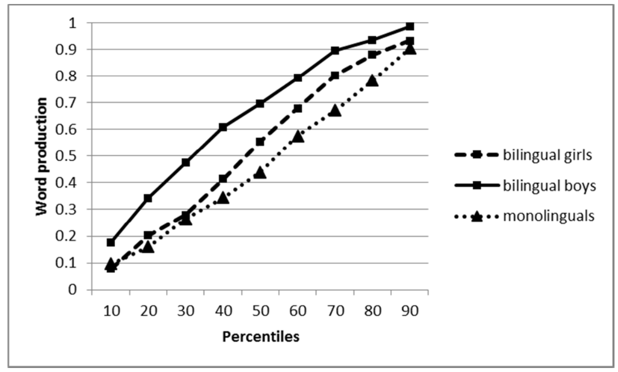

Word production
Percentiles
bilingual girls
bilingual boys
monolinguals

Figure 3