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Authors' contribution:

Alessandra Valentini and Ludovica Serratrice were jointly responsible for the conception and the design of the study, for the interpretation of the data, and for drafting and revising the manuscript.

Alessandra Valentini was solely responsible for the data collection and for the data analysis.

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Data and scripts are available at the following anonymous URL:

https://osf.io/x3wht/?view_only=ec90daba6584458e904eea7582f0b9c3

Abstract

Strong correlations between vocabulary and grammar are well attested in language development in monolingual and bilingual children. What is less clear is whether there is any directionality in the relationship between the two constructs, whether it is predictive over time, and the extent to which it is affected by language input. In the present study we analysed data from 100 bilingual children with English as an additional language who were tested on measures of vocabulary breadth and depth, morphology, and syntax at three time points at 6-month intervals from the age of 5;8. We used bivariate growth models to test the directionality of the relationship between vocabulary breadth and depth, and measures of morphology and syntax; testing bilingual children allowed us to use measures of English input as covariates in the analyses. All the models showed a correlation between vocabulary and grammar, but no correlation between their growth slopes, suggesting that vocabulary and grammar grow independently. Three of the four bivariate models showed a significant correlation between the intercept of grammar skills and the slope of vocabulary growth. Length of exposure to English predicted the intercept of vocabulary breadth and grammar, suggesting that children exposed to English earlier had larger vocabularies and better morpho-syntactic skills. Current English input predicted the intercept of both measures of vocabulary as well as the slope for vocabulary depth, the only measure for which there was a significant relationship between intercept and slope, suggesting a Matthew effect for this dimension of vocabulary.

Key Words

Vocabulary, grammar, bilingual, longitudinal, language development

1. Introduction

The relationship between vocabulary and grammar in children's language development has been a topic of theoretical interest for decades. Many studies have explored the relationship between measures of vocabulary - i.e. knowledge of words - and grammar – i.e. the knowledge of the structure of language - particularly in the early years (Bates, Bretherton, & Snyder, 1988; Dale et al., 2000; Labrell et al. 2014; Mcgregor, Sheng, & Smith, 2005; Moyle et al., 2007; Szagun et al., 2006). The majority of this work confirms a strong relationship between vocabulary and grammar skills, a positive correlation that has been reported cross-linguistically (Devescovi et al., 2005; Mariscal & Gallego, 2012; Stolt et al., 2009; Thordardottir, Weismer, & Evans, 2002), for both monolingual and bilingual children (Simon-Cereijido & Gutiérrez-Clellen, 2009; Marchman, Martínez-Sussmann, & Dale, 2004; Parra, Hoff, & Core, 2011). While the association between vocabulary and grammar is now well established, the directionality of the effect is far less clear. Research on bilingual toddlers has identified a role of input in mediating this relationship (Hoff, Quinn, & Giguere, 2018), but less is known about the role of relative amount of input in predicting vocabulary-grammar relationships over time and in older children from diverse L1 backgrounds. The present study aims to address the direction of the relationship between vocabulary and grammar in a group of bilingual school aged children speaking English as the language of schooling and a range of different home languages. Studying relatively older bilinguals allowed us to distinguish age effects from language input effects, over and above what has been previously established with monolingual (Brinchmann, Braeken, & Lyster, 2019) and younger bilingual children (Hoff et al., 2018).

1.1. Hypotheses on the directionality of the relationship between vocabulary and grammar

Some accounts posit a precedence of vocabulary over grammar, with vocabulary knowledge acting as the foundation of later grammar learning, and a subsequent linear relationship between the two (Caselli, Casadio, & Bates, 1999; Marchman & Bates, 1994; Szagun et al., 2006). For proponents of this lexicalist approach the onset of grammar is dependent on a critical mass of words, particularly verbs (Marchman & Bates, 1994; Tomasello, 2000). In a form of *lexical bootstrapping* the learning of new words with their associated morphology - and their argument structure in the case of verbs – lays the foundation for the development of multiword utterances.

Another possible way of conceptualising the directionality of the relationship between vocabulary and grammar is that the ability to exploit morphosyntactic information in the input is what allows children to learn new words. In a form of *syntactic bootstrapping* children use the morpho-syntactic information at their disposal to make an informed guess about the meaning of a word. The evidence for syntactic bootstrapping in early infancy (see Gleitman et al., 2005, for a review) suggests an influence of grammar on vocabulary development at early stages of development, albeit initially limited to a smaller set of familiar words. Evidence that older children between the ages of 5 and 7 (Casenhiser & Goldberg, 2005; Boyd & Goldberg, 2011; Wonnacott et al., 2012) – and adults too (Goldberg, Casenhiser, & Sethuraman, 2004; Boyd & Goldberg, 2009) – can use syntactic information to deduce the meanings of unfamiliar verbs provides further support for the role of syntactic bootstrapping past the earlier stages of lexical acquisition.

A third alternative is that the relationship between vocabulary and grammar is bidirectional with a two-way influence of vocabulary on grammar, and of grammar on vocabulary (Dionne et al., 2003; Moyle et al., 2007). Yet another possibility is that the growth of vocabulary and grammar is strongly correlated, synchronous, not causally related, and mediated by a third variable (Dixon & Marchman, 2007; Hoff et al., 2018).

1.2. Modelling evidence for directionality in the relationship between vocabulary and grammar

Developmental ordering is one way in which the directionality issue can be approached, but the majority of the studies in this area have used cross-sectional designs and investigated concurrent rather than longitudinal relationships (Dixon & Marchman, 2007; Pérez-Leroux, Castilla-Earls, & Brunner, 2012). In addition to considering a longitudinal design it is important to explore the type of analyses conducted: for example, a few longitudinal studies (Bates et al., 1988; Conboy & Thal, 2006) have only explored one possible direction of influence, specifically that from vocabulary to subsequent grammar.

In one early study, Bates et al. (1988) found that MLU at 28 months (a proxy for grammatical skills) was better predicted by vocabulary at 13 months than MLU at 20 months, but the reverse relationship between vocabulary and grammar at earlier time points was not investigated. A few recent studies have explored the relationship between vocabulary and grammar with the aim of determining directionality of influence (Brinchmann et al., 2019; Cadime et al., 2019; Caglar-Ryeng, Eklund, & Nergård-Nilssen, 2019; Dionne et al., 2003; Hoff et al., 2018; Marjanovič-Umek, Fekonja-Peklaj, & Socan, 2017; Moyle et al., 2007). Statistical analyses relying on cross-lagged panel models have typically been used in these studies to investigate the reciprocal relationships between vocabulary and grammar over time. Cross-lagged panel models are estimated using longitudinal data whereby each participant is recorded at multiple points in time. The models are "crossed", as they estimate relationships from one variable to another, and vice versa. They are "lagged" because they estimate relationships between variables across different time points. Taken together, cross-lagged panel models estimate the directional influence that variables have on each other over time. Dionne et al. (2003) used a cross-lagged panel model to study the relationship between vocabulary and grammar in English-speaking twins between the ages of 2 and 3, and found significant concurrent effects of grammar on vocabulary at both time points, but only an effect of vocabulary on grammar when children were 2 years old. When considering cross-lagged effects, they found an effect of vocabulary on subsequent grammar, but a negative, albeit small, effect of grammar on subsequent vocabulary. In a similar study Moyle et al. (2007) explored cross-lagged correlations between grammar and vocabulary in typically developing and late-talking children, finding a bidirectional relationship only before 3 years of age for typically developing children, but an initial influence of vocabulary on grammar, followed by an influence of grammar on vocabulary from 4 years of age, for the late-talking group. Using cross-lagged panel models, Caglar-Ryeng et al. (2019) explored the relationship between measures of vocabulary and grammar in children with a family risk of dyslexia and a control group between the ages of 1;6 months and 6;0 and reported bidirectional cross-lagged effects before the age of 3 years, but only cross-lagged effects of grammar over vocabulary after 3;6. In a study of children between 1;4 and 2;6 Cadime et al. (2019) reported a unidirectional significant relationship between vocabulary and MLU at 1;9 and sentence complexity at 2;1, with a stronger effect of vocabulary on these two measures of grammar. The only significant relationship with vocabulary at 2;1 was vocabulary at 1;9. In a similar longitudinal study with 51 toddlers between the ages of 1;4 and 2;7, Marjanovic-Umek et al. (2017) confirmed a predictive relationship between vocabulary between the ages of 1;4 and 2;7 and sentence complexity and MLU at 2;7.

These five studies seem to suggest an effect of vocabulary on grammar before 3, followed by a possible inversion of this relationship to a stronger effect of grammar on vocabulary at later time-points. However, as discussed by Brinchmann et al., (2019), following Hamaker, Kuiper and Grasman (2015), cross-lagged panel models do not account for trait-like stability of the constructs of vocabulary and grammar over time, and therefore they conflate within-person and between-person differences within the same model (see also Berry & Willoughby, 2017). In their own study Brinchmann et al. (2019) performed both simple cross-lagged panel models and random-intercept cross-lagged panel models. These latter models consider both direct effects from vocabulary at one time point to grammar at the subsequent time point, and vice-versa, as cross-lagged panel models do, but in addition they include a time-invariant parameter for both vocabulary and grammar. These parameters take into account trait-like stability of the constructs over time (i.e. the longitudinal consistency in the rank order of individual children), allowing to control for their relationship, over and above any time-variant association. This is particularly important as it allows to study the directionality of the relationship between vocabulary and grammar, and it accounts for the strong correlation between these two central constructs. Furthermore, these time-invariant constructs capture trait-like individual differences between participants (i.e. the individual variation in language skills between children that tends to be consistent over time), allowing the remaining time-variant effects to estimate within-subjects relationships over time. Using simple cross-lagged panel models Brinchmann et al. (2019) found that, between the ages of 4 and 6 there were bidirectional effects between vocabulary and grammar, while the model that also controlled for the stability of these constructs – i.e. the model that included the longitudinal consistency of the rank order of individual children - showed a significant and high correlation between the constructs of vocabulary and grammar at the between-person level, and only an effect of grammar on vocabulary from 4 to 5 years of age. Their results therefore further suggest an inversion of the earlier relationship between vocabulary and grammar, with stronger effects of bootstrapping in the grammar to vocabulary direction later in development.

In addition to considering trait-like stability to capture stable differences between individual children over time, it is important to pay attention to the overall shape of the growth of a construct over time, over and above any time-point relationship between constructs. The only study of this kind that considered both trait-like stability of the constructs, and the shape of the growth, in terms of the intercept and slope of a growth curve, is the study by Hoff et al. (2018). They measured vocabulary and grammar in Spanish-English bilinguals every six months from 30 to 48 months, with two measures of expressive vocabulary: a standardised test, the *EOWPT – Spanish-English Bilingual Edition,* and a caregiver report in both English - the CDI (Fenson et al., 2007) - and Spanish - the IDHC (Jackson-Maldonado et al., 2003). The CDI and the IDHC also provided two measures of grammar: a measure of grammatical complexity and the child's three longest utterances (ML3). Using bivariate latent-change score modelling Hoff et al. (2018) explored the relationship between the two constructs within and between languages. For English they found that better vocabulary skills correlated with better grammar skills, and faster growth of vocabulary correlated with faster growth in grammar, but there was no relationship between the intercept of one and the slope of the other, vocabulary skills did not predict grammar growth, and grammar skills did not predict vocabulary growth. This study therefore suggests that the two constructs are related but uncoupled, neither predicting the other, and – as previously found in other studies with bilingual children (Conboy & Thal, 2006; Marchman et al., 2004; Parra et al., 2011; Simon-Cereijido & Mendez, 2019) - within-language relationships between vocabulary and grammar were much stronger than between-language relationships.

1.3. Covariates of the relationship between vocabulary and grammar

As previously mentioned, when considering the relationship between these two constructs it is important to consider whether it is possible to determine causality, or whether the relationship might be affected by external factors influencing the development of both constructs. One variable that has been proposed as a possible predictor of the relationship between vocabulary and grammar is the amount and quality of language exposure (Dixon & Marchman, 2007; Hoff et al., 2018). Several studies have shown that the amount of exposure to a language correlates to a significant extent with the amount of vocabulary (Hurtado et al., 2013; Pearson et al., 1997) and morpho-syntactic knowledge in that same language (Huttenlocher et al., 2002). With specific reference to the directionality issue in the vocabulary-grammar association, Brinchmann et al. (2019) showed that the quality of the home literacy environment, as a proxy for quality of language exposure, correlated highly with trait-like stability of both vocabulary and grammar, while the inclusion of this variable did not seem to change the direction of this relationship. Studies on bilingual populations are particularly useful to isolate the effect of input: bilingual children may vary significantly in the relative exposure to each of their languages, while age and other cognitive aspects of their development remain constant. In their study of vocabulary and grammar development in young Spanish-English bilingual children, Hoff et al. (2018) argued that the effect of relative amount of language input on both vocabulary and grammar could explain the correlation between growth in the two constructs. However, the inclusion of relative amount of input in one language did not fully capture the variance explained by the correlation between grammar and vocabulary growth. Relative amount of input was not related to the slope of the growth in vocabulary and grammar, and it was only included in models of between-language effects, thus this study did not directly test the effect of language input on within-language relationships.

In the present study we focus on schoolchildren who have English as an additional language in the UK, a very heterogeneous group of bilinguals with varying degrees of exposure to a wide range of heritage languages at home, and different ages of first exposure to English - the language of schooling - depending on their migration history (see Bowyer-Crane et al., 2017; Burgoyne et al., 2009; De Cat, Gusnanto, & Serratrice, 2018; Dixon, Thomson, & Fricke, 2020; Serratrice & De Cat, 2019; Hessel, Nation, & Murphy, 2021, for recent studies on a similar population). Given the linguistic heterogeneity of the sample we could only focus on the language of schooling (English). In our analyses we included two measures of input: length of exposure to English (i.e. the amount of time children have been exposed to English) and relative current amount of English input (i.e. how much of their time children spend interacting in English during the week as a percentage of their total waking time). With the exception of De Cat et al. (2018) and Serratrice & De Cat (2019), studies on learners of English as an additional language in the UK have not considered input as a covariate in their analyses, and they have only used information on children's language backgrounds for descriptive purposes. Most of these studies aimed to compare bilingual and monolingual children, rather than to identify factors affecting variation within the bilingual group, thus adopting a dichotomous approach and categorising children as a function of their language background. They did not consider the effect of length of exposure to the societal language and/or of relative amount of exposure on their language skills. The purpose of the present study was not to compare monolingual and bilingual children, but rather to delve deeper into how different aspects of bilingual children's knowledge of their language of schooling, i.e. vocabulary and grammar, develop over time, and how this relationship is affected by their opportunity to hear and use the language. Here we go beyond the descriptive use of information, characterising the children's bilingual experience and using it as part of our modelling of the vocabulary-grammar relationship over time.

Another well-known predictor of both vocabulary and grammar proficiency in bilingual children – similarly to monolingual children - is SES measured by proxies like maternal education and occupation. In studies with bilingual school-age children SES has been repeatedly reported as a predictor of both vocabulary skills and grammar (De Cat, 2021; Gathercole et al., 2016; Meir & Armon-Lotem; 2017; Paradis & Jia, 2017). Given the importance of SES in previous research, we included both maternal education and the highest occupation in the household as covariates in our study. Age was also added as a covariate to control for effects of relative maturity on learning.

2. Aims of the study

The first aim of the present study was to investigate the longitudinal and reciprocal relationship between vocabulary and grammar in the language of schooling – English - for bilingual learners between the ages of 5 and 6. We considered both trait-like stability, as suggested by Brinchmann et al. (2019), and growth, as suggested by Hoff et al. (2018), by performing bivariate growth curve models with superimposed cross-lagged relationships. The models tested the following hypotheses: 1) that there are no predictive relationships between vocabulary and grammar, 2) that vocabulary development predicts later grammatical development, 3) that grammatical development predicts later vocabulary development, 4) that there are bidirectional predictive relationships between vocabulary and grammar.

Differently from previous studies, that mostly focussed on one aspect of both constructs under investigation, we considered measures of breadth and depth for vocabulary, and measures of morphological and syntactic knowledge for grammar. When considering vocabulary, the distinction between vocabulary breadth - i.e. the number of words in a speaker's lexicon - and depth - i.e. the extent of the knowledge linked to each item in the lexicon - is particularly significant in our study, as we explored vocabulary in primary school-aged children. There is evidence that these two aspects of vocabulary are separable and have distinct effects on story comprehension in younger children (Strasser & Del Rio, 2014), and on reading comprehension in older children and learners of English as a second language (Li & Kirby, 2014; Mehrpour, Razmjoo, & Kian, 2011; Ouellette, 2006). A recent study (Karlsen, Lyster, & Lervåg, 2017) showed that, while both breadth and depth of vocabulary knowledge grow similarly in bilinguals and monolinguals between the ages of 5 and 6, different environmental variables predict the two abilities at different ages.

For grammatical knowledge, we distinguished between morphological knowledge, i.e. knowledge regarding words' morphological features, and syntactic knowledge, i.e. knowledge regarding word order, as it is possible that these two aspects of structural language might be differentially linked to vocabulary, with morphological structures being more closely related to word knowledge (McBride-Chang et al., 2005).

The second aim of the present study was to capitalize on our bilingual population, where exposure to English and age of onset varied extensively, to investigate the role of the length of exposure and current amount of input as covariates in the relationship between vocabulary and grammar. Given the high amount of variability in English input in our sample, we expected this factor to explain a significant amount of variance in the children's language abilities and the correlation between vocabulary and grammar. Additionally, we considered possible effects of Socio-Economic Status (SES) - measured through maternal education and highest household occupation - and age on the development of lexical and grammatical abilities, as these variables are known to affect language development.

3. Methods

3.1. Participants

The initial sample included 100 children (48 girls) from 19 Year 1 classes in 9 schools in the South East of England. Children had a mean age of 5;8 (SD = .29) at their first testing session and all but two had completed the compulsory Reception Year that immediately precedes Year 1 in an English school. Nearly all of the children who continued to attend the same school completed all testing sessions, with 89 children still enrolled in the study at Time 3. Specifically, 5 children provided data only at Time 1, 5 children provided data at Time 1 and 2, but not Time 3, and one additional child completed all the testing at Time 1, but only part of the testing at Time 2, and no testing at Time 3 (for this child we have data on vocabulary breadth and morphological knowledge, but not vocabulary breadth and syntactic knowledge, at Time 2). A full information maximum likelihood approach was used for missing data. Children were invited to take part in the study if they were classified by their school as having English as an additional language (EAL) according to the definition of the UK's Department for Education, i.e. children "who were exposed to more than one language (which may include English) during early development". We deliberately decided to include bilingual children according to this broad definition to reflect the linguistic diversity of bi-multilingual children in primary schools in the UK. The children in the study spoke 28 different languages (43% Polish, 7% Hindi, 5% Arabic, 5% French, 5% Romanian, 4% Malayalam, 4% Nepali, 3% Bengali, 3% Punjabi, 3% Russian, 3% Tamil – 11% of the children spoke two languages other than English). To gather further information on children's multilingual background and relative exposure to English and any other language(s) we invited parents/guardians to complete a parental questionnaire (Serratrice & De Cat, 2019) which was completed in either English or Polish – the only language for which parents requested a translation. Eight parents did not return the questionnaire (thus we have missing data on English input measures, household occupation, and maternal education for 8 children); of those who returned the questionnaire, 3 did not complete questions of maternal education and occupation, and 15 did not provide occupation information but they gave information on maternal education and English input. A full information maximum likelihood approach was used for missing data.

3.2. Procedure

The project received ethical approval by the authors' university's research ethics committee. We invited all parents of children registered as having EAL within their school database, but who were not otherwise included in the Special Educational Needs register. All children whose parents accepted to take part by signing the consent form were included in the research after giving verbal assent. Children in the sample had no known language or cognitive difficulty according to parents' and teachers' reports.

Data collection was completed in the 2017-18 (Year 1) and 2018-19 (Year 2) school years. Children were assessed at three time-points: autumn-winter of Year 1 (Time 1), spring-summer of Year 1 (Time 2) and autumn-winter of Year 2 (Time 3). All measures of vocabulary and morpho-syntactic abilities were collected at all time points as part of a larger testing battery. The full testing battery was divided between two testing sessions at each time point, on average 9 days apart at Time 1 and Time 3, and 6 days apart at Time 2. Testing took place in a quiet area within the school and all children completed the tasks in the same given order.

3.3. Materials

3.3.1. Tests

Vocabulary breadth was assessed by the BPVS-3 (Dunn, Dunn, & NFER, 2009). This test requires the identification of the picture for a given word amongst four alternatives. The score was computed as the total number of words correctly recognised.

Vocabulary depth was measured by the Synonyms and the Opposites subtests from the TOWK (Wiig & Secord, 1992). These tasks require the selection of the correct synonym or antonym for a given word. In both tasks words are presented in writing and the experimenter read aloud both the given word and the alternatives. The subtests were scored separately and the total score for vocabulary depth was computed as the mean of the two scores.

The Word Structure subtest from the CELF-4-UK (Semel, Wiig, & Secord, 2006) was used as measure of morphological knowledge. This task requires production of the final word in a given sentence with its correct morphological ending. The score was the number of items correctly completed.

For syntactic knowledge we administered the short version of the Test of Reception of Grammar (TROG – 2; Bishop, 2003; see Whiteside & Norbury, 2017 for TROG short). In this task children are required to select the picture that correctly matches a spoken sentence amongst four alternatives. The total score was the number of correct items.

3.3.2. Parental Questionnaire

Parents completed a questionnaire providing demographic information and estimating amount of exposure to English and their other language(s). The questionnaire was adapted from Serratrice and De Cat (2019) and it is available at the following URL: https://osf.io/x3wht/?view_only=ec90daba6584458e904eea7582f0b9c3. We asked parents about occupation and education, and, as a proxy for SES, we used the highest occupation in the household following the Standard Occupation Classification of the UK Office for National Statistics (https://onsdigital.github.io/dp-classification-tools/standard-occupational-classification/ONS_SOC_occupation_coding_tool.html). As this classification yields lower scores for the higher earning occupations, scores were reversed in the analyses, for clarity.

To explore the effect of English input, we extrapolated two measures: the current amount of English input (in percentage points) and length of exposure to English, computed as the number of months of exposure to English calculated from age of first exposure (i.e. the difference between age at Time 1 and age of first exposure). To estimate the amount of current English input we asked parents to indicate who spoke to the child, in which language, and how often over the course of the week. For the weekly report we used a five-point scale (never, rarely, half of the time, usually, always) then converted into percentages (never = 0, rarely = 25%, half of the time = 50%, usually = 75%, always = 100). The current amount of input in English was the sum of the number of hours they spent with each interlocutor over the week multiplied by the percentage of time the child heard English from each and then divided by the total number of hours the child was assumed to be awake – assuming 14 hours a day. For the time spent at school (6 hours a day) we assumed that the child only heard English. Questionnaires were distributed at Time 1, and collected between Time 1 and Time 2. Ideally it would have been desirable to collect measures of relative amount of input at three time points, but this was not possible due to resource limitations and the lack of direct access to the parents.

3.4. Data analysis

Data and R scripts for all the analyses in this manuscript are available at the following anonymous URL: https://osf.io/x3wht/?view_only=ec90daba6584458e904eea7582f0b9c3

For each variable, a linear growth model comprising of both an intercept and a linear slope was estimated using the package lavaan (Rosseel, 2012) in R (R core Team, 2019). A full information maximum likelihood approach was used to deal with missing values for both endogenous and exogenous variables, by specifying exogenous variables as random; the software estimated a likelihood function for each participant based on the data collected. This model included all possible significant covariates: age at Time 1, mother's education, highest household occupation (henceforth occupation), length of exposure to English (English length exposure) and current amount of English input (English current input) were entered in the model if they significantly correlated with a given outcome measure. The significance of the linear growth was assessed by the comparison of this model with a model containing only an intercept but not a slope (no growth model) as suggested by Grimm, Ram and Estabrook (2017). Quadratic growth did not improve fit in any model (all *p*s > .100, except for Vocabulary Depth, where a full model including quadratic growth fit the data significantly worse than a full model with linear growth: χ^2 (8) = 240.61, $p < .001$, $AIC_{quad} = 2984$; $AIC_{linear} = 2760$), thus it will not be discussed further. After determining the best fitting model in terms of growth, the influence of the covariates was estimated, by removing non-significant covariates and assessing model fit, until the best fitting simplest model was estimated. Regression parameters between Time 1 and Time 2 and Time 2 and Time 3 were included in these unimodal growth model for ease of comparison with subsequent bimodal growth models.

After computing the best model for each variable (univariate growth models), we computed bivariate growth models including one vocabulary measure and one grammar measure in turn, to determine the longitudinal relationship of vocabulary and grammar. These models included an estimate of the relationship between slopes and intercepts in the two constructs, as well as estimates for the relationship between the intercept of one construct and the slope of the other. Finally, we estimated the parameters that indicated the effect of the level of one construct at each time point on the level of the other construct at the subsequent time point, in order to assess the longitudinal effect of one variable on the other over time. Four models were computed to test our hypotheses: 1) a bivariate growth model without any direct path between the two constructs, which would indicate that the two constructs are correlated but neither leads to the other directly at any given time point beyond the relationship between their intercepts and growth; 2) a bivariate growth model with direct paths from vocabulary to subsequent grammar scores, which would indicate vocabulary precedence over grammar; 3) a bivariate growth model with direct paths from grammar to vocabulary, which would indicate a precedence of grammar over vocabulary; 4) a bivariate growth model including all possible direct paths. These models were compared, and the simplest, best fitting model was retained. As was the case with the unimodal growth models, regression parameters between each variable at Time 1 and Time 2 and between Time 2 and Time 3 were included, to ensure any relationship between different variables between time points would capture between-variables relationship, rather than within-variable between time points relationships.

5. Results

Table 1 presents means and standard deviations for all the measures, as well as the results of the test of normality. The exploration of distribution graphs did not indicate any floor or ceiling effects. Correlations between the measures are reported in Table 2. Covariates were centered around the mean in all analyses, but raw means and standard deviations are reported for ease of interpretation.

Table 1. Mean (and Standard Deviations) for the measures described in the present study

		Time 1			Time 2			Time 3		
		Mean (SD)	Shapiro-Wilk normality test		Mean (SD)	Shapiro-Wilk normality test		Mean (SD)	Shapiro-Wilk normality test	
			W	*p*		W	*p*		W	*p*
Covariates	Mother Education (N = 89)	3.36 (.81)	.74	< .001	-	-	-	-	-	-
	Occupation (N = 74)	6.43 (3.41)	.89	< .001	-	-	-	-	-	-
	Age Time 1 in months (N = 100)	68.40 (3.50)	.97	.011	-	-	-	-	-	-
	English length exposure in months (N = 92)	45.62 (19.01)	.94	< .001	-	-	-	-	-	-
	English current input % (N = 92)	53.76 (18.13)	.92	< .001	-	-	-		-	-
Language Skills	Vocabulary Breadth	68.83 (15.57)	.99	.601	77.67 (14.46)	.98	.192	84.83 (15.90)	.97	.024
	Vocabulary Depth	8.51 (4.62)	.94	< .001	12.36 (5.04)	.99	.387	15.14 (5.90)	.98	.271
	Morphological Knowledge	14.53 (6.23)	.99	.323	18.03 (5.29)	.97	.047	21.17 (5.01)	.94	< .001
	Syntactic Knowledge	22.21 (8.01)	.97	.030	25.80 (7.96)	.92	< .001	28.78 (6.52)	.89	< .001

For all covariates raw means and SDs are reported, but analyses are computed with mean-centered variables.

Table 2. Spearman correlations between the measures

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Covariates	1 - Mother Education	-	-.68*	.08	.24	.34*	.28*	.31*	.18	.29*	.22	.41*	.28	.33*	.25	.36*	.41*	.36*
	2 - Occupation		-	.19	.31*	.48*	.38*	.29	.18	.23	.35*	.34*	.24	.28	.33*	.27	.32*	.28
	3 - Age Time 1			-	.27*	.09	.13	.32*	.15	.19	.20	.16	.18	.19	.21	.17	.10	.16
	4 - English length exposure				-	.58*	.55*	.38*	.47*	.43*	.50*	.46*	.49*	.36*	.54*	.31*	.48*	.35*
	5 - English current input					-	.57*	.31*	.35*	.37*	.56*	.43*	.32*	.31*	.58*	.36*	.46*	.40*
Time 1	6 - Vocabulary Breadth						-	.59*	.71*[a]	.69*	.88*[a]	.73*[a]	.62*	.58*	.85*	.70*[a]	.62*	.54*
	7 - Vocabulary Depth							-	.63*	.60*	.55*	.66*	.56*	.60*	.64*	.67*	.48*	.57*
	8 - Morphological Knowledge								-	.66*	.70*[a]	.67*[a]	.80*	.69*	.73*	.68*[a]	.71*	.62*
	9 - Syntactic Knowledge									-	.65*	.68*	.63*	.76*	.72*	.66*	.65*	.71*
Time 2	10 - Vocabulary Breadth										-	.71*[a]	.60*	.59*	.83*	.69*[a]	.61*	.51*
	11 - Vocabulary Depth											-	.67*	.65*	.68*	.78*[a]	.69*	.61*
	12 - Morphological Knowledge												-	.74*	.67*	.65*	.82*	.68*
	13 - Syntactic Knowledge													-	.62*	.64*	.68*	.81*
Time 3	14 - Vocabulary Breadth														-	.72*[a]	.71*	.64*
	15 - Vocabulary Depth															-	.63*	.62*
	16 - Morphological Knowledge																-	.68*
	17 - Syntactic Knowledge																	-

Correlations significant at <.01
[a]Pearson correlations are reported as both measures were normally distributed

5.1. Growth models

5.1.1. Vocabulary breadth

The best fitting model for vocabulary breadth was a model that included a linear slope as well as an intercept, and that included English length of exposure and English current input as covariates (χ^2 (3) = 3.30, p = .347, CFI = .999, TLI = .997, RMSEA = .032 (95% CI: .000–.175), SRMR = .025, BIC = 2585.28). This model had better fit than a model that predicted no growth (χ^2 (6) = 13.76, p = .033). English length of exposure (χ^2 (2) = 9.34, p = .009) and English current input (χ^2 (2) = 55.15, p < .001) as covariates significantly improved the model, while mother's education and occupation did not (χ^2 (4) = 2.64, p = .619).
English length of exposure and English current input significantly predicted the intercept (Length exposure: β = .27, p = .006; Current input: β = .46, p < .001), but not the slope (Length exposure: β = .25, p = .255; Current input: β = .31, p = .315), indicating English length of exposure and current input had an effect on the scores in vocabulary breadth, but did not influence its growth. This is consistent with the lack of correlation between intercept and slope (r = .31, p = .279), and the lack of significant variance in the slope (σ = 15.16, p = .096), which suggests that all children had a similar growth, independently of their starting point and their level of English input. The model confirmed that there was high variability in children's vocabulary skills, and that there was significant growth from Time 1 to Time 3, as the intercepts for both intercept and slope were significant (Intercept: β = 68.77, p <.001; Slope: β = 25.45, p = .007), and the variance for the intercept was significant (σ = 137.51, p < .001).

5.1.2. Vocabulary depth

The best fitting model for vocabulary depth was a linear growth model with English current input and age as covariates (χ^2 (4) = 2.38, p = .666, CFI > .999, TLI > .999, RMSEA

< .001 (95% CI: .000 – .118), SRMR = .028, BIC = 2154.97). The linear growth model fit the data better than a model that predicted no growth (χ^2 (8) = 15.69, *p* = .047). Mother's education and occupation as covariates did not significantly improve the model ($\chi 2$ (4) = 5.33, *p* = .255), nor did English length of exposure ($\chi 2$ (2) = 4.82, *p* = .90), while age ($\chi 2$ (2) = 8.10, *p* = .017) and English current input (χ^2 (2) = 7.08, *p* = .029) did.

In the final model, the intercept was significantly predicted by both English current input (β = .39, *p* < .001) and age (β = .31, *p* = .001), while the slope was only predicted by English current input (β = .36, *p* = .012), not age (β = - .01, *p* = .975), indicating that scores in vocabulary depth were influenced by both English input and age, while growth was only determined by English current input. The model also highlighted a significant relationship between slope and intercept (*r* = .38, *p* = .017), suggesting that children with deeper vocabularies showed greater levels of growth than children with shallower vocabularies. Both intercepts and variances were significant for both the intercept and the slope in the model (Intercept: β = 8.52, *p* < .001, σ = 13.08, *p* < .001; Slope: β = 6.47, *p* < .001, σ = 5.43, *p* = .015), indicating that, not only did children start at different levels of vocabulary depth, but the growth was not consistent for all participants. The regression between Time 1 and Time 2 (β = -.27, *p* = .025) and between Time 2 and Time 3 (β = -.43, *p* = .009) was also significant; the negative value of this relationship suggests that there was a relative deceleration of growth over time, compared to the linear growth highlighted by the significant linear slope, but the inclusion of a quadratic growth term in the final model did not improve model fit (χ^2 (4) = 1.09, *p* = .896). In summary, vocabulary depth grew more over time for those children with deeper vocabulary knowledge and higher levels of current English input at the start of the study.

5.1.3. Morphological knowledge

The best fitting model for morphological knowledge was a linear growth model with English length of exposure as covariate (χ^2 (2) = .91, p = .633, CFI > .999, TLI > .999, RMSEA < .001 (95% CI: .000 – .157), SRMR = .012, BIC = 1823.45). The linear growth model had better fit than a model that predicted no growth (χ^2 (7) = 55.03, p < .001). Mother's education and occupation did not significantly improve the model (χ^2 (4) = 2.02, p = .732), nor did English current input (χ^2 (2) = 1.42, p = .492), while English length exposure (χ^2 (2) = 20.43, p < .001) did.

In the final model, the intercept was significantly predicted by English length of exposure (β = .54, p < .001), while the slope was not (β = .15, p = .465), indicating that scores in morphological knowledge were influenced by length of exposure to English, but growth was not. Intercept and slope were not significantly correlated (r = -.23, p = .261), suggesting that the level of morphological knowledge did not determine growth. The model confirmed that there was high variability in children's morphological knowledge, that there was significant growth from Time 1 to Time 3, and that there was considerable individual variation in the growth of morphological knowledge, as the intercepts and variances for both intercept and slope were significant (Intercept: β = 14.55, p <.001, σ = 25.71, p <.001; Slope: β = 6.36, p < .001, σ = 2.57, p = .001).

5.1.4. Syntactic knowledge

The best fitting model for syntactic knowledge was a linear growth model with English length of exposure as covariate (χ^2 (4) = 5.31, p = .257, CFI = .992, TLI = .988, RMSEA = .057 (95% CI: .000 – .170), SRMR = .059, BIC = 2076.22). The linear growth model had a better fit than a model that predicted no growth (χ^2 (5) = 18.73, p = .002). Occupation (χ^2 (2) = 1.75, p = .416) and maternal education (χ^2 (2) = 3.94, p = .140) did not significantly improve the model. Of the measures of English input, English current input did not improve the model (χ^2 (2) = 2.35, p = .309), while English length of exposure (χ^2 (2) = 9.73, p < .001) did.

In the final model, the intercept was significantly predicted by length of exposure to English (β = .50, p < .001), while the slope was not (β = -.18, p = .571), indicating that scores in syntactic knowledge were influenced by English input, but growth was not. The correlation between intercept and slope was set to 0, for convergence problems, given that it was not significant in the initial, non-convergent model (r = -.66, p = .190). The variance of the slope was also set to 1, as it produced convergence problems. The final model confirmed that there was high variability in children's syntactic knowledge and that there was significant growth from Time 1 to Time 3 (Intercept: β = 22.21, p <.001, σ = 38.36, p <.001; Slope: β = 5.19, p < .001).

5.2. Bivariate models

5.2.1. Vocabulary breadth and morphological knowledge

Fig. 1 presents the best fitting bivariate linear growth model between vocabulary breadth and morphological knowledge. Models that included either a direct effect of vocabulary on subsequent grammar (χ^2 (2) =1.75, p = .417) or grammar on subsequent vocabulary (χ^2 (2) = 1.92, p = .382) did not improve model fit.

In the final model there was a significant correlation between the intercept of vocabulary breadth and morphological knowledge (r = .60, p < .001), but not their slopes (r = -.30, p = .365), furthermore there was a significant correlation between the intercept of morphological knowledge and the slope of vocabulary breadth (r = .59, p = .031), but not between the intercept of vocabulary breadth and the slope of morphological knowledge (r = -.06, p = .752). This suggests that children with larger vocabularies also had better morphological skills, but the two abilities grew relatively separately. On the other hand, children with better morphological knowledge also tended to have a steeper growth in vocabulary breadth than children with poorer morphological knowledge.

English input was included in the model and maintained the same relationship with vocabulary and morphological knowledge showed in the growth models for these variables (i.e. scores in vocabulary breadth and morphological knowledge were influenced by initial amount of English input, but growth was not).

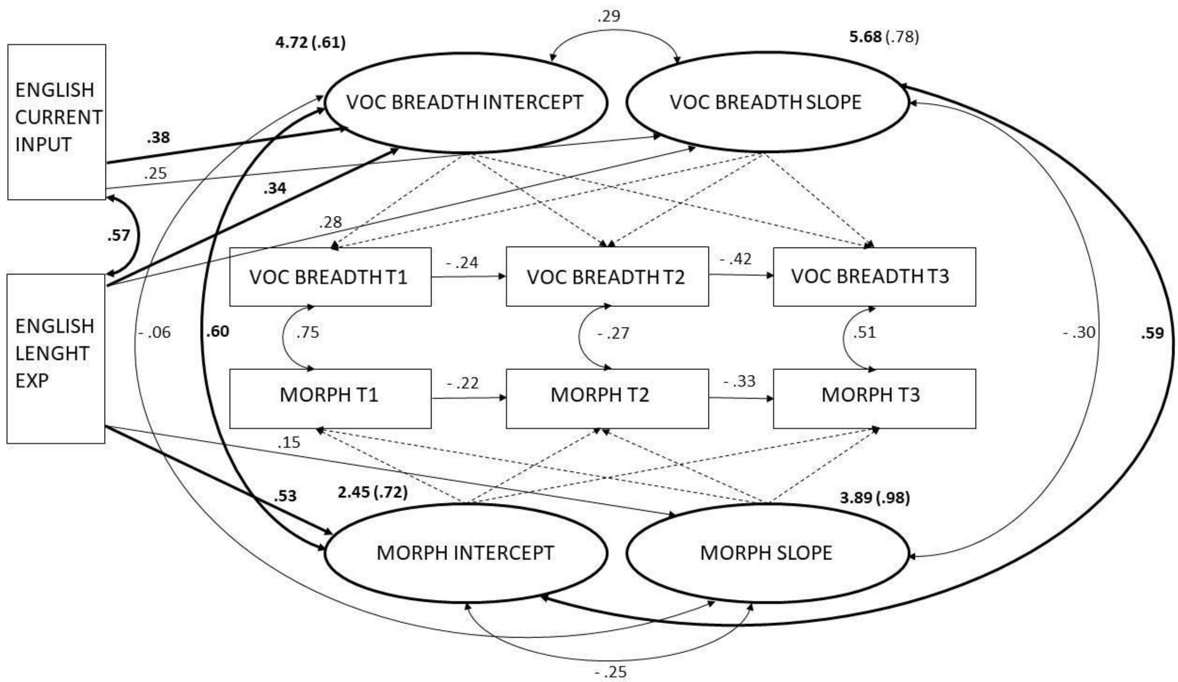

Figure 1. Bivariate growth model with vocabulary breadth and morphological knowledge (χ^2 (10) = 9.96, p = .444, CFI > .999, TLI > .999, RMSEA < .001 (95% CI: .000 – .108), SRMR = .040, BIC = 4103.52)

5.2.2. Vocabulary depth and morphological knowledge

Fig. 2 presents the best fitting bivariate linear growth model between vocabulary depth and morphological knowledge. Models that included either a direct effect of vocabulary depth on subsequent morphological knowledge (χ^2 (2) = 4.10, p = .129) or morphological knowledge on subsequent vocabulary depth (χ^2 (2) =.23, p = .893) did not improve model fit. In the final model, as for the simpler growth model, intercept and slope of vocabulary depth were correlated (*r* = .37, *p* = .017), English current input predicted the intercept (β = .29, *p* = .001) and the slope (β = .27, *p* = .026) of vocabulary depth, and English length of exposure predicted morphological knowledge (β =.41, *p* < .001). Furthermore, age predicted the intercept of vocabulary depth (β =.27, *p* = .001). There was also a significant correlation between the intercept of vocabulary breadth and morphological knowledge (*r* = .64, *p* < .001), but not their slopes (*r* =.15, *p* = .605), and there was a significant correlation between the intercept of morphological knowledge and the slope of vocabulary depth (*r* = .53, *p* = .003), but not between the intercept of vocabulary depth and the slope of morphological knowledge (*r* = -.18, *p* = .482). This suggests that, as was the case for vocabulary breadth, children with deeper vocabularies also had more morphological knowledge, but the two abilities grew relatively separately. On the other hand, children with better morphological knowledge also tended to have a steeper growth in their vocabulary depth than children with lower levels of morphological knowledge.

The measures of English input maintained the same relationship with vocabulary depth and morphological knowledge showed in the growth models for these variables (i.e. English length of exposure influenced scores in morphological knowledge, but not growth, while English current input was related to both scores and growth in vocabulary depth).

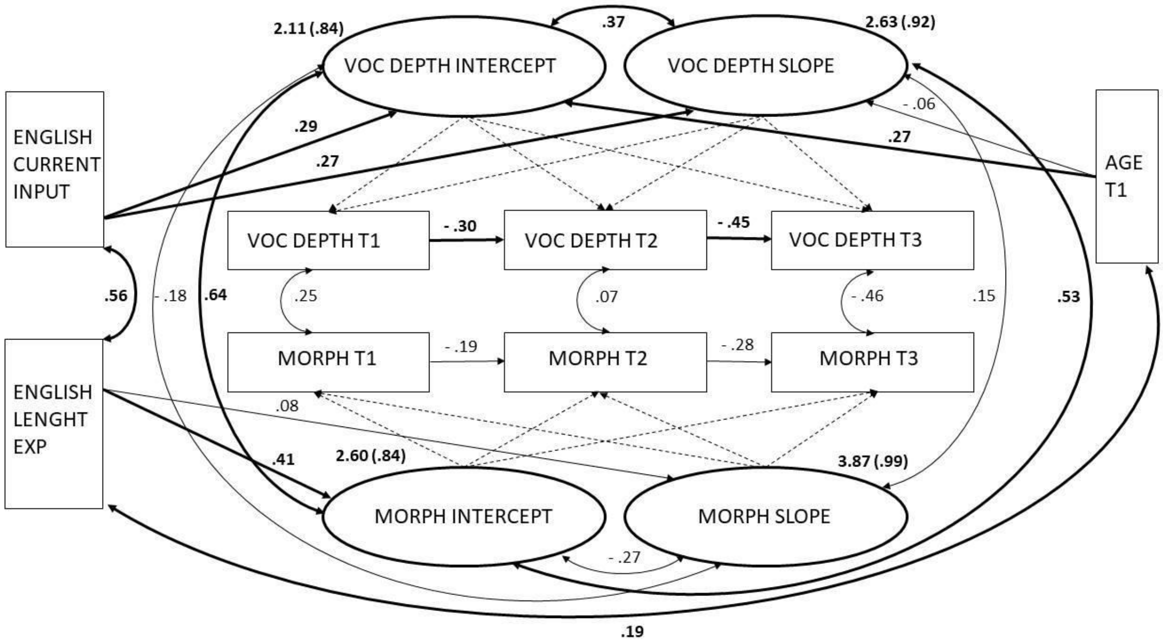

Figure 2. Bivariate growth model with vocabulary depth and morphological knowledge (χ^2 (17) = 25.57, p = .083, CFI = .984, TLI = .967, RMSEA = .071 (95% CI: .000 – .124), SRMR = .071, BIC = 3913.71)

5.2.3. Vocabulary breadth and syntactic knowledge

Fig. 3 presents the best fitting bivariate linear growth model between vocabulary breadth and syntactic knowledge. Models that included either a direct effect of vocabulary on subsequent grammar (χ^2 (2) = 3.20, p = .202) or grammar on subsequent vocabulary (χ^2 (2) = 2.50, p = .286) did not improve model fit.

In the final model there was a significant correlation between the intercept of vocabulary breadth and syntactic knowledge (r = .61, p < .001), while the correlation between their slopes could not be freely estimated, due to model non-convergence, and was therefore set to 0, as it was not significant in the full non-convergent model (r = -.96, p = .199). Similarly, the correlation between the slope for syntactic knowledge and the intercept for vocabulary breadth was set to 0, due to non-convergence, but was not significant in the original model (r = -.28, p = .414). The correlation between the intercept of syntactic knowledge and the slope of vocabulary breadth did not cause convergence problems, and was approaching significance (r = .52, p = .060). This suggests that children with larger vocabularies also had more syntactic knowledge, but the two abilities grew relatively separately.

The measures of English input maintained the same relationship with vocabulary breadth and syntactic knowledge showed in the growth models for these variables (i.e. scores in vocabulary breadth were influenced by both measures of English input and scores in syntactic knowledge were influenced by English length of exposure, but growth in either measures was not influenced by measures of English input).

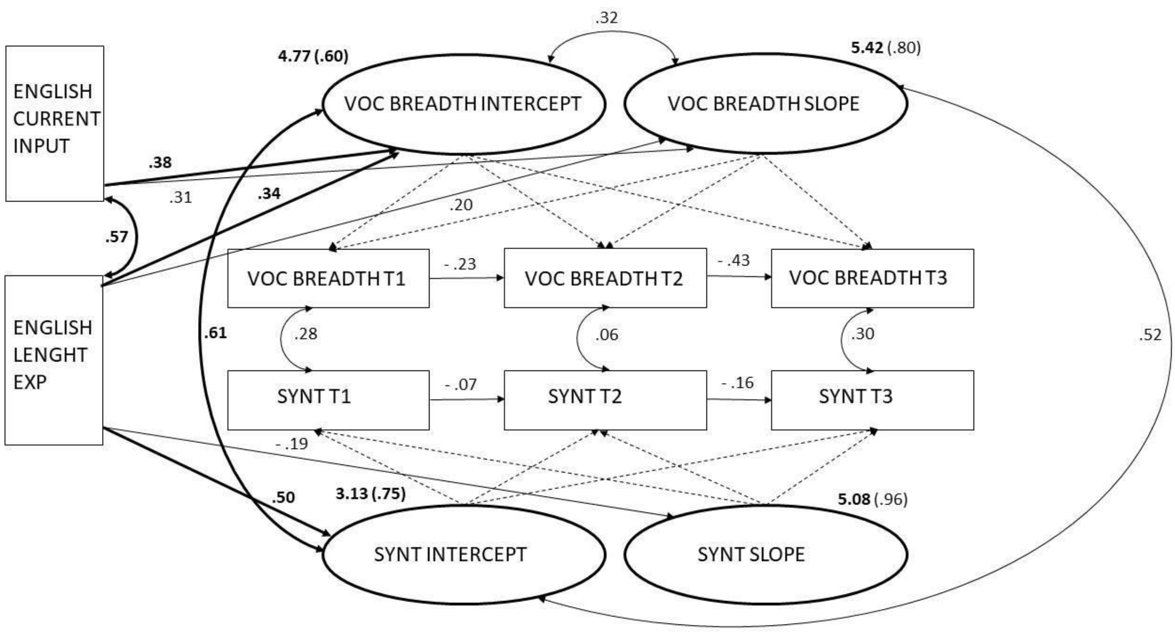

Figure 3. Bivariate growth model with vocabulary breadth and syntactic knowledge (χ^2 (14) = 19.52, p = .146, CFI = .991, TLI = .981, RMSEA = .063 (95% CI: .000 – .123), SRMR = .060, BIC = 4357.33)

5.2.4. Vocabulary depth and syntactic knowledge

Fig. 4 presents the best fitting bivariate linear growth model between vocabulary depth and syntactic knowledge. Models that included either a direct effect of vocabulary depth on subsequent grammar (χ^2 (2) = 2.58, p = .275) or grammar on subsequent vocabulary depth (χ^2 (2) =.86, p = .651) did not improve model fit.

In the final model, as for the simpler growth model, intercept and slope of vocabulary depth were correlated (r = .41, p = .015), English current input predicted the intercept of vocabulary depth (β = .27, p = .003), while it only approached significance for its slope (β = .23, p = .084) and English length of exposure predicted the intercept of syntactic knowledge (β =.32, p = .001). Age only predicted the intercept of vocabulary depth (β =.25, p = .003). Furthermore, there was a significant correlation between the intercept of vocabulary depth and syntactic knowledge (r = .67, p < .001), but not their slopes (r = -.19, p = .740), and there was a significant correlation between the intercept of syntactic knowledge and the slope of vocabulary depth (r = .59, p = .009), but not between the intercept of vocabulary depth and the slope of syntactic knowledge (r =.13, p = .767). This suggests that children with deeper vocabularies also had better syntactic knowledge, but the two abilities grew relatively independently. Children with better syntactic knowledge also tended to have a steeper growth in their vocabulary depth than children with lower levels of syntactic knowledge, while growth in syntactic knowledge was not linked to vocabulary depth skills.

English input maintained the same relationship with vocabulary depth and syntactic knowledge showed in the growth models for these variables (i.e. English current input influenced vocabulary depth, while English length of exposure influenced syntactic knowledge).

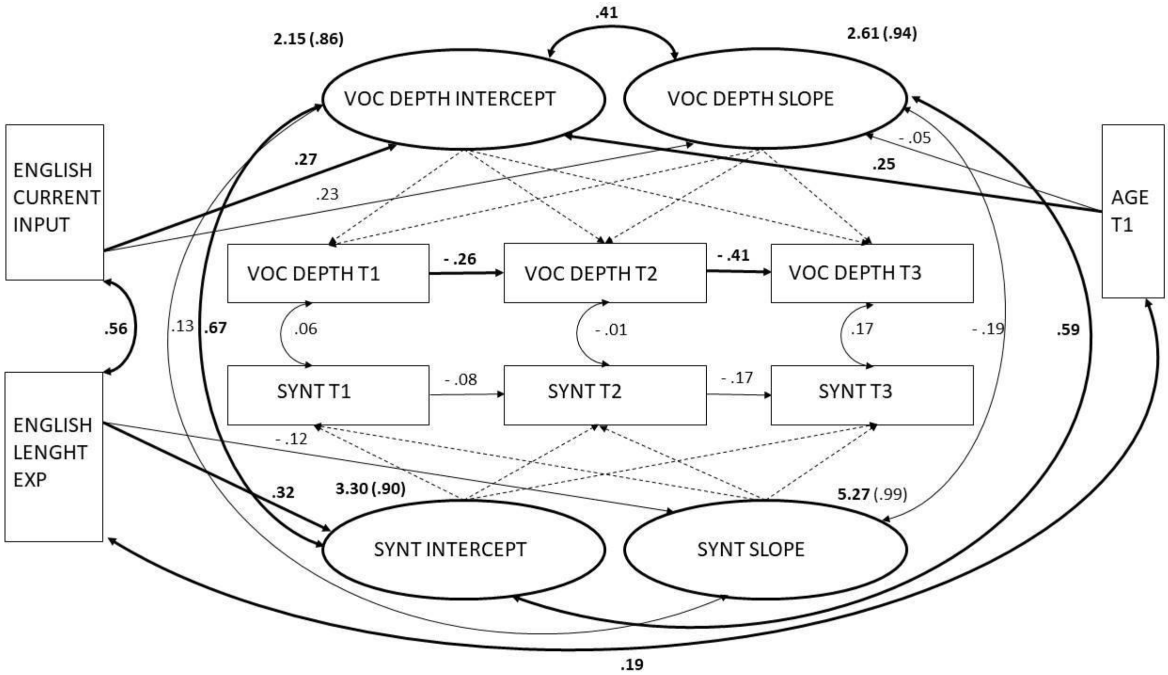

Figure 4. Bivariate growth model with vocabulary depth and syntactic knowledge (χ^2 (19) = 25.84, p = .135, CFI = .985, TLI = .971, RMSEA = .060 (95% CI: .000 – .113), SRMR = .122, BIC = 4175.45)

5.3 Summary of the results

Table 3 and Table 4 summarise the results of the previous sections.

Table 3

Summary of the results of the unimodal growth models

Construct	**Predictors of Intercept**	**Predictors of Slope**	**Relationship between Intercept and Slope**
Vocabulary Breadth	-English Current Input -English Length of Exposure	None	None
Vocabulary Depth	- English Current Input -Age at Time 1	- English Current Input	Positive Correlation between Intercept and Slope
Morphological Knowledge	- English Length of Exposure	None	None
Syntactic Knowledge	- English Length of Exposure	None	None

Table 4

Summary of the results of the bimodal growth models

Relation	Cross Lagged Predictors	Time-invariant associations
Vocabulary Breadth <-> Morphological Knowledge	None	-Correlations in average proficiency -Correlation between average morphology proficiency and average vocab breadth growth
Vocabulary Depth <-> Morphological Knowledge	None	-Correlations in average proficiency -Correlation between average morphology proficiency and average vocab depth growth
Vocabulary Breadth <-> Syntactic Knowledge	None	-Correlations in average proficiency
Vocabulary Depth <-> Syntactic Knowledge	None	-Correlations in average proficiency -Correlation between average morphology proficiency and average vocab depth growth

6. Discussion

The first aim of the present study was to capitalise on a population of bilingual school-age children to investigate the directionality of the relationship between the development of vocabulary and grammar. By including bilingual children in our study, we were able to address our second aim and make a new contribution to our understanding of the role of length of exposure and current amount of input in the well-established association between these two constructs.

6.1 The longitudinal relationship between vocabulary and grammar

In a series of bivariate growth curve models with superimposed cross-lagged relationships we tested the following hypotheses: 1) that there are no predictive relationships between vocabulary and grammar, 2) that vocabulary development predicts later grammatical development, 3) that grammatical development predicts later vocabulary development, 4) that there are bidirectional predictive relationships between vocabulary and grammar.

All of the bivariate growth models showed a correlation between vocabulary and grammar, but failed to show any correlation between their growth, suggesting that vocabulary and grammatical skills were correlated in these bilingual children, but that these abilities grew independently. Three out of four of the models (vocabulary breadth and morphological knowledge, vocabulary depth and morphological knowledge and vocabulary depth and syntactic knowledge) also showed time-invariant correlations between grammar skills and vocabulary growth, with the fourth model showing a correlation that neared significance (see Table 4). However, we found no direct effects from grammar measured at any earlier time point (i.e. Time 1 and Time 2) to subsequent vocabulary scores (i.e. vocabulary scores at Time 2 and Time 3).The lack of a direct effect from earlier measures of grammar to later measures of vocabulary (i.e. from grammar at Time 1 to vocabulary at Time 2 or from grammar at Time 2 to vocabulary at Time 3) would suggest that there was no primacy of grammar over vocabulary in this age range. Nevertheless, the link between the intercept of grammar and the growth in vocabulary found across our models suggests that children with higher levels of grammar also grew more in their vocabulary than children with lower grammar abilities, thus seeming to support our third hypothesis. Importantly, the reverse correlations between the intercept of vocabulary and grammar growth were not significant. Considering these two results together we can hypothesize that grammar levels might have an effect on vocabulary growth over time. This conclusion is in line with several studies that used cross-lagged panel model to establish temporal precedence between vocabulary and grammar that only found effects of earlier grammar on later vocabulary after the age of 3 (Brinchmann et al., 2019; Caglar-Ryeng et al., 2019; Moyle et al., 2007). Interestingly, by taking into account not only the time-invariant relationship between vocabulary and grammar, but also the overall growth of the constructs over time, our study suggests a broader link between children's grammar abilities and the amount of vocabulary growth in general, without any effect at any specific time point. The lack of direct effect from grammar to subsequent vocabulary at any time point in our study could be in fact due to the integration of this more general effect of grammar level on vocabulary growth, which might subsume any time-specific effect. The only other study to explore the relationship between vocabulary and grammar considering not only trait-like stability, but also the relationship between this and the growth of the constructs (Hoff et al., 2018) was conducted with younger bilingual children, up to the age of 4, and found no relationship between intercepts and amount of growth, either within or between constructs when these were assessed in English. The difference between Hoff et al.'s (2018) results and those of the present study is not entirely surprising as the relationship between vocabulary and grammar seems to change over time, with longitudinal studies with children younger than 3 usually showing either a bidirectional relationship or a primacy for vocabulary (Cadime et al., 2019; Dionne et al., 2003; Marjanovic-Umek et al., 2017). It is possible that this change might be linked to exposure rather than age, which would suggest that bilingual children might show the directional switch later as a function of reduced relative amount of input. This idea is supported by the literature on the importance of exposure for language growth (Grüter & Paradis, 2014), but not by the results of Hoff et al. (2018), who found no links between intercepts and growth of vocabulary and grammar, suggesting a decoupling between the two.

Overall, our bivariate models suggest that, irrespective of the dimension of vocabulary (breadth and depth) and aspect of grammatical knowledge (morphology or syntax) assessed, the relationship between them appears identical, albeit with the possible exception of the relationship between syntactic knowledge and vocabulary breadth. Specifically, in bilingual children between five and seven years of age, those with better grammatical knowledge also have better vocabulary knowledge, and vice-versa, and those with better grammar skills also tend to have steeper growth in vocabulary. The correlation between grammar skills and vocabulary growth, but the lack of correlation between vocabulary skills and growth in grammatical knowledge, seems to suggest an effect of grammatical primacy in this age range.

To explain the relationship between grammar knowledge and vocabulary growth over time we need to consider that vocabulary growth at more advanced stages is mostly driven by the acquisition of new morphologically inflected forms, rather than new root words (Anglin, 1993; Carlisle, 2007; Nagy & Anderson, 1984). In this case children's ability to recognise and use suffixes and affixes would positively influence vocabulary development, by allowing children to more easily deduce the meaning of new words. This might be particularly relevant for receptive tasks like those in the present study: children might not have been able to produce all the words presented, but the ability to deconstruct the words between their root and their morphological endings might have helped them extrapolate the meaning of lesser known items. Research on the use of morphology-based intervention to increase vocabulary in school age children support the idea that understanding the morphological structures of words is an important factor in vocabulary development in children during the school years (e.g.: Baumann et al., 2003; Bowers & Kirby, 2010; Harris, Schumaker, & Deshler, 2011; James et al., 2020).While the relationship between vocabulary growth and syntactic knowledge might be less straightforward to explain, we could hypothesise that knowledge of syntactic structures might free attentional resources for the children to focus on new vocabulary items presented in their linguistic environment. Knowledge of complex syntactic rules might even allow the children to access and comprehend more advanced reading material, which, in turn, would provide them with exposure to more complex vocabulary.

The interpretation of grammatical primacy in our study, however, is tempered by the nature of the relationship highlighted in the model: as the relationship illustrated by our models is correlational, we cannot directly demonstrate that levels of grammar knowledge determine vocabulary growth, as the opposite interpretation, that is, that levels of vocabulary growth determine levels of grammatical knowledge, could also be true. However, this interpretation seems less likely, as it is unclear how the level of growth in one construct might influence not the level of growth in another, but its overall time-invariant level. The fact that vocabulary knowledge did not correlate with grammatical growth also seems to point against this interpretation. A second limit to the interpretation of grammatical primacy from our results stems from the fact that, while our models allowed for both within and between-subjects relationships between vocabulary and grammar, only the between-subject relationship were significant. Therefore, while we can say that children with higher levels of grammatical knowledge tend to grow more in vocabulary than their peers, we cannot directly establish that, within each individual child, grammar determines vocabulary development. While it is possible that, as previously argued, any time-specific within-subject relation between vocabulary and grammar at the individual level has been incorporated in our less time-dependent constructs, it is also possible that the relationship between grammar and vocabulary can be found at the population level, but not at the individual level.

6.2 The effect of length of exposure and current amount of English input in the vocabulary-grammar relationship

In the bivariate models, current input significantly predicted the intercept of both vocabulary breadth and vocabulary depth, and length of exposure predicted the intercept of morphological and syntactic skills as well as vocabulary breadth. However, when it comes to the slope of growth the only significant predictive relationship was between current input and vocabulary depth.

When we considered the relationship between vocabulary and grammar, we found a correlation between grammar skills and vocabulary growth, but no correlation between vocabulary skills and growth in grammatical knowledge. This result holds even when taking into account the effect of current English input and length of exposure on both constructs, thus refuting the idea that input might completely explain the relationship between vocabulary and grammar. Even when considering the effect of English current input and length of exposure on the intercept and the slope of both vocabulary and grammar, our models still show a consistent relationship between the two constructs. English current input and English amount of exposure therefore emerge as significant factors in explaining the amount of vocabulary and morpho-syntactic knowledge showed by the primary school aged children in our study, but they do not completely explain the relationship between levels of vocabulary and grammar or that between levels of grammar and growth in vocabulary knowledge, which seems therefore to emerge as a direct relationship between the two.

6.3 The effect of length of exposure and current amount of English input on individual vocabulary and grammar constructs over time

In addition to investigating the role of input in the vocabulary-grammar relationship we also considered what effect length of exposure and current input would have on the intercept and growth of the individual vocabulary and grammar constructs. As expected, the results of the univariate growth models show that all skills measured (vocabulary breadth, vocabulary depth, morphological knowledge, and syntactic knowledge) increased throughout the period examined. The growth of these skills was linear, without decrement over time. Vocabulary breadth, and morphological and syntactic skills increased similarly for all participants, without any difference between lower and higher achieving children. In contrast, growth in vocabulary depth was positively correlated with the depth of children’s vocabularies, in a pattern that could be described as a Matthew effect: children with deeper vocabularies increased their vocabulary depth over time more rapidly than children with shallower vocabularies. Despite the significant linear growth of this skill over time, the negative relationship between vocabulary depth at subsequent time points suggests that there might be a slight deceleration of its growth over time. Given each skill was only measured over three time points, it is not possible to comment further on the relative shape of growth, which would be best addressed by longer longitudinal investigations. The results for vocabulary breadth and both morphological and syntactic growth appear similar to those shown by the younger bilingual children in Hoff et al.'s study (2018), where there was no significant correlation between initial levels and growth in any of these skills, when tested in English.

English input predicted both vocabulary and grammar skills, with children with higher exposure to English obtaining higher scores at all time points, but different measures predicted different skills. Length of exposure emerged as the best predictor of both morphological and syntactic knowledge, while vocabulary depth was only predicted by current amount of exposure, and vocabulary breadth was predicted by both measures. Furthermore, no measure of English input predicted growth in vocabulary breadth and either measure of grammar: children grew in these skills similarly, independently of the amount of English they were exposed to, probably due to relatively stable exposure to the language they all received during the school day after the age of 4. This was not, however, the case for vocabulary depth, which increased more rapidly in children with higher current amount of exposure. Age also predicted the intercept for vocabulary depth, suggesting, on the whole, that older children and those exposed to more English during their week had deeper vocabularies, and those with deeper vocabularies and higher exposure to English, in turn, increased their vocabulary depth faster than less skilled children and those with less English input. In contrast to the results of Karlsen et al. (2017), we did not find different effects of environmental variables on vocabulary depth and breadth at different time points, but rather a more pronounced effect of both environmental (language exposure) and internal variables (age) on vocabulary depth, with effects not only on skills at each time point, but amount of growth over time.

To interpret the different effect of length of exposure and current amount of input on vocabulary and grammar measures we consider the different nature of these dimensions of language knowledge. While grammatical knowledge is characterised by a relatively limited set of constructions, vocabulary knowledge is not finite in the same way. In our study length of exposure to English predicted both measures of grammar knowledge, suggesting that children exposed to English from an earlier age might have mastered English grammatical constructions that children newer to English had yet to acquire, this is in line with studies with other bilingual children (Chondrogianni & Marinis, 2011). Length of exposure did not have an effect on the depth of children's vocabulary, which was instead positively associated with current amount of exposure to English, in line with previous research on vocabulary acquisition in bilingual children (Chondrogianni & Marinis, 2011; Thordardottir, 2019). The refining and deepening of children's vocabulary takes place over time, and requires encountering words in many different contexts (Mak, Hsiao, & Nation, 2021), thus the amount of exposure, rather than when a word was first encountered, is of higher importance for building semantic networks and the linguistic knowledge that relates to them. Vocabulary breadth was influenced by both measures of input: both length of exposure and current amount of exposure can predict the probability of a child encountering new words, and thus leading to an increase in the number of words in their repertoire.

6.4. A note on the different dimensions of lexical knowledge: breadth and depth

Because we included two different dimensions of vocabulary, we need to address the difference between the patterns of growth within breadth and depth. This is where the concept of lexical quality becomes relevant. The lexical quality hypothesis (Perfetti & Hart, 2002) suggests a differentiation between words with high lexical quality, for which participants have stored a range of features in memory - including phonological and orthographic forms, general and nuanced meaning and collocations - and words lower in lexical quality, which are associated with a more limited amount of information, and whose links with other words and concepts are less well developed. Vocabulary depth tasks assess the quality of the vocabulary represented in memory, especially in terms of semantic relationships, in contrast to the more quantity-oriented measure of vocabulary breadth, which assesses only a shallower level of knowledge, i.e. whether the word exists in the child's lexicon at all. The bilingual children in this study, independently from their starting point, increased their vocabulary size steadily over time. On the other hand, those who started with less vocabulary knowledge, and a more sparsely connected semantic lexicon, struggled to develop deeper vocabulary knowledge compared to the children who started with more words (breadth), but, more crucially, more knowledge regarding these words and their conceptual links (depth). This finding is consistent with the idea that forming a general representation of a word is easier than forming a more nuanced and well-developed representation. While the development of a deep vocabulary might rely on previous knowledge, with children building on their knowledge of known words to develop their understanding of new ones, learning new labels less deeply might proceed without excessive reliance on previous vocabulary.

6.5. Limitations and final remarks

The first limitation of this study is that we only assessed the bilingual children in one of their languages and therefore we cannot address potential relationships across languages. While this is indeed a limitation, it is one that is very difficult to address in the context of the extreme heterogeneity of the bilingual population of school age children in the UK. Our sample is representative of a typical mainstream primary school classroom in areas with a high percentage of EAL learners, in this respect, it presents a snapshot of the current state of bilingual schoolchildren in the country. At the same time, English is the only language of schooling for the vast majority of bilingual learners in the UK and therefore this limitation is one that nonetheless has some practical implications as teachers and parents need to know what reasonable expectations of growth over time to have for these bilingual learners.

Another limitation is that we only assessed language exposure once at the beginning of the study. However, given that information regarding this predictor were collected mostly between Time 1 and Time 2 we believe our measure is a reliable estimate of current exposure throughout the study given its relative short longitudinal duration and considering that all children had already attended a whole school year before the study started.

A final limitation is the relatively small sample size, which might account for relative lack of power in the more complex analyses; however, given similar number of participants and analyses in previous research (Hoff et al., 2018; Lauro, Core, Hoff, 2020), and the relative stability of the results over multiple analyses in the present study, we believe the current results give convincing insights into the relationship between vocabulary and grammar in young bilingual learners of English.

In conclusion, studying a bilingual population has allowed us to investigate the role of current amount of English input and length of exposure to English as significant predictors of bilingual children's language skills in vocabulary and grammar, highlighting how length of exposure tends to predict grammar levels, while current amount of input is more correlated with vocabulary. All of the bivariate growth models showed a correlation between vocabulary and grammar, but they failed to show any correlation between their growth. At the same time, our two measures of English input predicted the intercept for lexical and morpho-syntactic skills respectively. Exposure to the language simultaneously provides learners with access to both lexical and morpho-syntactic information and as such input is a likely candidate to explain the strong correlation between vocabulary and grammar. However, measures of input alone do not completely explain the relationship between the intercept of grammar level and the growth in vocabulary, especially vocabulary breadth, as neither measure of English input have a direct effect on its growth. It seems that vocabulary and grammar have a strong relationship beyond what is explained by their relative predictors; for example it could be that a good level of grammatical knowledge might support the ability to make informed guesses about the meaning of new vocabulary.

With specific reference to the nature of the relationship between dimensions of vocabulary and grammar, another important highlight of the present research is the difference between vocabulary breadth and depth in terms of their development. While all children seem able to develop their vocabulary breadth and indeed their grammatical knowledge equally well once they enter school, children with lower initial vocabulary depth, with lower current amount of exposure to English, and those who are relatively younger, might lag behind in vocabulary depth over time. This finding will likely have repercussions on reading comprehension (Mehrpour et al. 2011; Ouellette, 2006), and it is therefore likely that children with less robust vocabulary depth will be most vulnerable in building on this aspect of oral language for written language comprehension.

Finally, our research reveals a link between children's grammar levels and their vocabulary growth, suggesting that, to support vocabulary development, focussing on the development of grammar knowledge, especially morphological knowledge, might be the key to increase vocabulary growth in primary school children.

(10566 words)

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