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Extra-linguistic modulation of the English noun-bias: Evidence from Malaysian bilingual infants and toddlers.

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Abstract

Early vocabularies typically contain more nouns than verbs. Yet, the strength of this noun-bias varies across languages and cultures. Two main theories have aimed at explaining such variations; either that the relative importance of nouns vs. verbs is specific to the language itself, or that extra-linguistic factors shape early vocabulary structures. To address this debate, the present study compares the relative distribution of verbs and nouns within the same language – English – between Malay-English and Mandarin-English bilingual infants and toddlers. The English receptive lexicons of Mandarin-English bilingual children contained more verbs than those of Malay-English bilinguals, suggesting that the noun-bias is modulated by factors external to English. We discuss the potential role of socio-cultural differences on the composition of children early vocabularies.

Keywords: Language Development; Infancy; Language specificity; Socio-cultural influences; Cross-cultural studies

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Extra-linguistic modulation of the English noun-bias: Evidence from Malaysian bilingual infants and toddlers.

Over the past decades, researchers have documented that young children tend to acquire nouns before verbs across a range of languages: English (Gentner, 1982), German, Italian (Caselli et al., 1995) or Spanish (Jackson-Maldonado, Thal, Marchman, Bates, & Gutierrez-Clellen, 1993) and that they are able to learn novel nouns at a quicker pace than novel verbs, in English (Childers & Tomasello, 2002). Gentner (1982) suggested this noun bias to be universal, as infants may find it simpler to label concrete objects than to learn verbs, that typically describe relationships between objects. Hence, the acquisition of nouns would be a precursor to verb learning.

Yet, numerous studies have shown that noun learning does not always outperform verb learning. While multiple languages are considered "noun-friendly" (e.g., English, Spanish) – children's early vocabularies contain more nouns than verbs – studies on the acquisition of Korean, Cantonese and Mandarin as first languages have suggested these languages to be "verb-friendly" (Arunachalam et al., 2013; Chen et al., 2015; Choi & Gopnik, 1995; Tardif, Gelman, & Xu, 1999; Tardif et al., 2008) – with nouns and verbs equally prevalent in early vocabularies (Choi & Gopnik, 1995; Tardif, 1996; Chen et al., 2015, Tardif, Gelman, & Xu, 1999; Tardif, Shatz, & Naigles, 1997) – and with more verbs than among noun-friendly languages (Choi & Gopnik, 1995; Tardif et al., 2008; Tardif et al., 1997). These findings suggest that the strength of

the noun bias varies across languages and cultures, rather than being a language universal phenomenon (Lavin et al., 2006).

Tardif et al. (1999) showed that 20-month-old toddlers of Mandarin-speaking mothers tend to use verbs more often whereas toddlers of English-speaking mothers tend to use nouns more often. Correspondingly, English-speaking mothers also tend to use nouns more frequently than verbs when talking to their children whereas Mandarin-speaking mothers tend to favour verbs over nouns. While this correspondence suggests infants exposed to a noun-friendly language acquire an early lexicon rich in nouns, it does not explain why some languages are noun-friendlier than others.

Researchers have suggested that attentional patterns differ across culture, hence impacting the composition of early vocabularies: Westerners tend to focus their attention on objects—typically referred to with nouns—whereas Asians tend to focus more on the relationship between objects—often described using verbs (Nisbett & Miyamoto, 2005). Additional studies provided further demonstration of culture-dependent attentional structures (Ji, Peng, & Nisbett, 2000; Nisbett, 2004). Similarly, Waxman et al. (2016) discovered that when a video was being shown, 24-month-old Chinese infants attended to more actions-related elements whereas American infants focused more on the objects involved. Such differences in attentional pattern can also modulate children's abilities to learn words. In a study by Chan, Tardif, Chen, Pulverman, Zhu and Meng (2011), Mandarin-learning infants at 18 months were better at associating novel words to actions, whereas English-learning infants did better in mapping novel words to objects. Together, these studies suggest that differing attentional patterns across cultures can manifest as

a learner's bias that may be modulating infant lexical development. Such differences are external to the linguistic properties of a language – we will refer to those as *extra-linguistic* factors.

Other extra-linguistic factors may also be driving differences in early lexical composition across languages and cultures. Using the "Human Simulation Paradigm" (Gillette, Gleitman, Gleitman, & Lederer, 1999), Snedeker, Li and Yuan (2003) investigated the ability of adults to correctly guess the target words (equal proportion of nouns and verbs) from silent videos depicting play session between a mother and an infant. They showed that both English- and Mandarin-speaking adults were better at identifying nouns than verbs from silent videos of English infant-directed speech. Yet, when exposed to silent videos of Mandarin infant-directed speech, both Mandarin- and English-speakers had similar performance when identifying nouns and verbs. Snedeker et al.'s (2003) results suggest that extra-linguistic information may account for the presence of a noun-bias in the vocabularies of English-learning children, while early vocabularies of Mandarin-learning children would be more balanced.

In parallel, other researchers have argued that factors *intrinsic* to a language can also impact the early word acquisition process (e.g., morphological transparency, pronoun-dropping parameter, word order; Tardif, Shatz, & Naigles, 1997; Tardif et al., 1999; Tardif, 1996). For example, Mandarin (but not English) is a pronoun-dropping language that allows the omission of pronouns, making verbs more likely to appear at the salient front or end of a sentence, depending whether the subject or object was omitted (Tardif, Shatz, & Naigles, 1997), in turn putting the emphasis on the verb.

Italian, despite also being a pronoun-dropping language, is a noun-friendly language. Yet, its rich verbs inflections relative to nouns, favours the learning of nouns over verbs, according

to Tardif, Shatz, & Naigles (1997). English, with limited noun inflections and richer verbs inflections (Gentner, 1982) can also be seen as favouring the acquisition of nouns, making English a noun-friendly language. In contrast, Mandarin hardly has any verb or noun inflections, thus reducing the asymmetry between noun and verb inflection complexity, in turn making Mandarin a verb-friendly language. Additionally, verbs in Mandarin are often enhanced by participles, further enhancing the notion of verb in the sentence.

Our brief review of the literature suggests that both language-intrinsic features and socio-cultural influences may impact children's acquisition patterns of nouns and verbs. Crucially, these language differences appear to correlate with the attentional structure displayed across cultures. Hence, a direct comparison of participant vocabularies across languages usually will not allow for an assessment of the relative contribution of language-intrinsic factors (syntax, morphology) and language-extrinsic factors (attentional patterns, extra-linguistic context) on the noun- (or verb-) bias.

One promising avenue is then to assess bilingual children, as this allows researchers to evaluate potential differences in the noun-bias of two languages within a single learning environment. Xuan and Dollaghan (2013) collected parental reports on Mandarin-English bilingual children raised in the USA. They found that the expressive lexicons in Mandarin contained more verbs than in English, while an analysis of the 50 most frequent words in English contained more nouns than in Mandarin. They concluded that the noun-bias is language-specific, as other potentially confounding factors such as socio-economic status did not vary within subject. Yet, as bilingual children in the study may have learned their languages from two different speakers (or in two learning contexts, e.g., Mandarin at home, and English

in a day-care), they may have been provided with distinct extra-linguistic cues when learning both languages. Both language-intrinsic and language-extrinsic factors may be playing a role in creating differences in the lexicons of children across language groups.

To dissociate language specificity from extra-linguistic cues, bilinguals should ideally be learning both languages from the same caregiver. Chan and Nicoladis (2010) addressed this issue, as they followed longitudinally two Mandarin-English bilingual children who were learning both languages from the same person, thereby providing enhanced control over extra-linguistic cues when assessing language-specific factors in the noun bias. They found both children to use more nouns than expected from the analysis of the salient position in their input utterances, for both of their languages. The authors suggested that the parents, immigrants to Canada, were acculturating to a western style of communication, hence potentially reducing the highlighting of verbs in their non-verbal behaviour that would otherwise be observed in monolingual Mandarin-speaking parents (Snedeker, Li, & Huan, 2003). While results from Chan and Nicoladis (2010) highlighted a correspondence between the input children were exposed to and their developing lexicon, their results also suggested that the social-cultural contexts in which children are being raised (in that case, Chinese immigrants acculturating to a western culture) modulate the noun-bias in languages they are learning.

The aim of the present contribution is to further examine the role of socio-cultural influences on language acquisition patterns, in particular on the noun bias. While previous studies with bilingual children have taken the approach of assessing differences across their languages learnt within a single learning environment (e.g., Chan & Nicoladis, 2010; Xuan & Dollaghan, 2013), we adopt the distinct, and complementary, approach of considering the

impact of socio-cultural differences in their learning environment when learning a common language.

To this end, we focus on the English learnt by two groups of bilingual children from two distinct socio-cultural environments – raised in Chinese-ethnic families and in Malay-ethnic families in Malaysia[1]. Malay is an Austronesian language with a morphological complexity between that of Mandarin and English; Malay relies on both noun and verb inflections of word stems to produce complex meaning, but unlike nouns, which can be used in its bare stem forms, most verbs have to be inflected in order to denote actions (Tadmor, 2009). Yet, similar to Mandarin, Malay does not inflect verbs for tenses nor nouns for marking the singular-plural distinction but relies on separate markers to do so. Consequently, we expected that language-intrinsic factors would make Malay more noun-friendly than Mandarin yet more verb-friendly than English (a secondary aim of the present study being to verify this hypothesis). Crucially, differences in the ratio of verbs to nouns in the English lexicons across these two groups of children, as indexed by parental reports, would thus suggest that extra-linguistic factors can modulate the English noun bias.

Methods

Participants

Participants were 514 Malaysian infants and toddlers (248 females and 266 males). Participants came from middle and upper-middle socio-economic backgrounds and were born full term. Since the focus of the study is not on bilingualism *per se*, but rather in comparing

[1] Note; all infants and toddlers in the study are *Malaysian*, i.e., citizens of Malaysia, a multicultural country. Some of them speak Mandarin, whereas others speak *Malay* (Bahasa Malaysia).

socio-cultural influences on language structure, we adopted a generous inclusion criterion; infants classified as bilinguals were defined as having non-zero exposure to two languages. Relative exposure to English, as reported by their parents, was similar across bilingual groups ($t(38.77) = 1.59$, $p = .12$).

All Malay learners were ethnically Malay and all Mandarin learners ethnically Chinese. 117 children were exposed to Malay only, with an age range between 7 and 45 months of age ($M = 24.80$, $SD = 8.43$); 22 were exposed to Mandarin only, with an age range between 15 and 45 months of age ($M = 23.00$, $SD = 5.15$); 297 were exposed to both Malay and English, with ages ranging from 6 to 48 months ($M = 24.00$, $SD = 8.43$); and 78 were exposed to both Mandarin and English with an age range of 7 to 45 months of age ($M = 22.50$, $SD = 8.43$). While our age range extends beyond traditional limits for the application of MacArthur-Bates Communicative Development Inventories (CDIs; Fenson et al., 1996), analyses restricted to children younger than 36 months of age led to the same pattern of results.

To increase sample size and assess the noun-friendliness of Malay in comparison to other languages, we extracted additional Mandarin and English production data from WordBank (Frank et al., 2016). 85 monolingual Mandarin-speaking Chinese infants and toddlers (48 males and 37 females) were sampled randomly from WordBank. Their ages ranged from 16 to 30 months of age ($M = 23.25$, $SD = 4.25$). 85 English-speaking monolingual American infants and toddlers (45 males and 40 females) were also sampled randomly from the Wordbank with ages ranging from 16 to 30 months ($M = 23.07$, $SD = 4.07$). The American CDI data was collected by Thal, Marchman, Tomblin, Rescorla, and Dale (2013) and Fenson and Marchman (2007). The Chinese data was collected by Tardif, Fletcher, Liang, and Kaciroti (2009). Our sample size and

age range did not allow for a comparison of the noun-friendliness of these languages in comprehension (with just 10 Malay monolinguals between 12 and 16 months of age – the common age range between our sample and that of comprehension data associated with Mandarin and English in Wordbank).

Apparatus and Materials

Data was collected using a trilingual adaptation of the MacArthur-Bates Communicative Developmental Inventories (Fenson et al., 1996). This adaptation, thereafter referred to as the MCDI-M (Multilingual Communicative Development Inventories – Malaysia version), was developed by Low (2010) to assess simultaneously three languages frequently encountered in Malaysia; Mandarin, Malay and English. This adaptation contains 600 words spanning different categories, in each of the three languages. Parents were asked to assess both production and comprehension of the words on the MCDI-M. Ethics approval was granted by The University of Nottingham Institutional Ethics Board (JM190315).

Coding

Nouns were counted based on the definition of Caselli et al. (1995). Nouns were stringently defined; only noun categories that represent concrete objects (animal names, vehicles, toys, food and drink, clothing, body parts, small household items, furniture and rooms and outside things) were included. Nominal categories (names for people, people and locations) were excluded from analyses. Verbs were counted from the action words category. Table 1 reports the number of words in each category from the MCDI-M.

When performing comparisons with data from WordBank, we identified the common set of nouns and verbs across all three language data sets (Malay, Mandarin and English), as the exact set of words in a CDI modulates the ratio of verbs to nouns V/N. Words from the same taxonomic level were included for comparison (e.g., candy and sweets), while words from different hierarchical levels (e.g., cereals and cornflakes) were excluded from the final sample which included 78 verbs and 156 nouns.

--- Insert Table 1 around here ---

Analyses

Our Malaysian infants and toddlers constituted four language groups: a monolingual Malay language group, a monolingual Mandarin language group, a bilingual Malay-English group, and a bilingual Mandarin-English group. We computed a verb-to-noun ratio[2] for each participant (V/(N+V)), based on parental reports for vocabulary in both comprehension (Table 2) and production (Table 3). To account for a potential over-representation of null V/(N+V) ratios (young participants may not have verbs in their vocabularies yet - hence a V/(N+V) ratio of zero), we built zero-inflated negative binomial models (ZINBM) on the V/(N+V) ratio in early lexicons, using the *glmmTMB* function (Brooks et. al., 2017) in *R* (R Core Team, 2016). The V/(N+V) ratios were converted to percentages and rounded to the nearest integers to conduct the ZINBM. Zero-inflation models essentially decompose the analysis into two parts: the first part evaluates factors and covariates that predict the occurrence of zeros (we refer to

[2] We will loosely refer to V/(N+V) as a "verb-to-noun ratio" thereafter. V/(N+V) was preferred over V/N in order to include in the analyses infants whose early vocabularies may still not include any nouns yet (and thus where V/N would not be defined).

this as being the zero-inflated part of the model). The second part evaluates factors and covariates predicting the distribution of non-zero values (we will refer thereafter to the latter part of the analyses as the "distributional" part of the model). Since the full model with age, language group and interactions did not converge, we implemented ZINBM multiple linear regression models – with age (coded as a continuous variable) and language group (comparisons in pairs, see Q1 – Q3 for language pairs; and Tables 4 – 14 for reference groups) as fixed-effect variables for both the zero-inflation[3], and the non-zero distribution of V/(N+V) ratios.

Analyses were conducted to address the following questions:

1. Is the English V/(N+V) ratio among Malay-English bilinguals different from the English V/(N+V) ratio among Mandarin-English bilinguals? A significant difference between language groups would suggest that extra-linguistic factors can modulate the language noun bias (in our case, in English).
2. Is the Malay V/(N+V) ratio among Malay monolinguals different from that of Malay-English bilinguals? Similarly, is the Mandarin V/(N+V) of Mandarin monolinguals different from that of Mandarin-English bilinguals? Significant differences would suggest that languages of bilingual learners influence each other in terms of noun-friendliness and hence that a language noun bias can be dissimilar for monolinguals and bilinguals.

[3] Younger children are expected to know fewer verbs than older children; children learning a noun-friendly language are expected to know fewer verbs than children learning a verb-friendly language.

3. Is the Malay V/(N+V) ratio among Malay learners different from that of the Mandarin V/(N+V) ratio among Mandarin learners? A significant difference between language groups would suggest that the noun-friendliness of Malay is different from the noun-friendliness of Mandarin.

In addition, our analyses will establish how noun-friendly is Malay, when compared to both Mandarin (verb-friendly) and English (noun-friendly) using supplemental data from WordBank (Frank, Braginsky, Yurovsky, & Marchman, 2016) in Mandarin[4] and American English.

Results

A two-step procedure was applied to analyse the data in *R* (R Core Team, 2020). First, a test of zero-inflation was run on the distributions of verb-to-noun ratios using the *zero.test* function from the *vcdExtra* package (Michael, 2017). In the presence of zero-inflation, zero-inflated negative binomial models (ZINBM) were then used to investigate differences in verb-to-noun ratios between language groups. Linear mixed models (LMM) were used when distributions were not zero-inflated.

Q1 – Does the English V/(N+V) ratio among Mandarin-English bilinguals differ from the English V/(N+V) ratio of the Malay-English bilinguals?

[4] There are two versions of Mandarin CDIs in WordBank, one created in Beijing and the other in Taiwan. In the present study we have used the Beijing version as a comparison.

Our first research question was to find out whether the English V/(N+V) ratio among Mandarin-English bilinguals differed from the English V/(N+V) ratio of the Malay-English bilinguals. The tests for the presence of zero-inflation were significant for both production and comprehension ($p < .001$), hence zero-inflation models were used.

In comprehension, the zero-inflation part of the ZINBM did not reveal an effect of age ($p = .94$) but an effect of language group ($p = .01$). Mandarin-English bilingual children were more likely than Malay-English children to possess verbs in their vocabularies. Crucially, the "distributional" part of the model (when children possess at least one verb in their vocabulary) did not reveal an effect of age ($p = .15$) but revealed an effect of language group on the English V/(N+V) ratio ($p = .011$). It is noteworthy that, while the English of both bilingual groups contained more nouns than verbs (see Table 3), the English of Mandarin-English bilinguals was richer in verbs than the English of Malay-English bilinguals (see Table 4). Thus, both the zero-inflation and the distributional parts of the model indicated significant differences between groups in comprehension (see Figure 1), suggesting that extra-linguistic factors can modulate the English noun bias.

In production, the ZINBM analyses revealed that both age ($p < .001$) and language group ($p = .002$) were significant predictors of excessive zeros. Older children and Mandarin-English bilinguals were more likely to produce verbs. Once vocabularies contained verbs (as revealed by the "distributional analyses") neither language group ($p = .25$) nor age ($p = .89$) were significant predictors of the English V/(N+V) ratio (see Table 5 and Figure 2). The English of Mandarin-English bilinguals was comparable to the English of Malay-English bilinguals, in terms of the proportion of verbs in their productive vocabularies. Thus, in production the zero-inflation but

not the distributional parts of the model indicated significant differences between groups. Considering comprehension and production together, there is more evidence than not suggesting that extra-linguistic factors can modulate the English noun bias.

Q2 – Do verb-to-noun ratios differ between monolinguals and bilinguals?

Our second research question was whether the verb-to-noun ratios would differ between monolinguals and bilinguals. To address this question, we compared the Malay V/(N+V) of Malay monolinguals to that of Malay-English bilinguals, and the Mandarin V/(N+V) of Mandarin monolinguals to that of Mandarin-English bilinguals.

For the Malay learners, the tests for the presence of zero-inflation were significant for both production and comprehension ($p < .001$), hence zero-inflation models were used. In comprehension, age (p = .003) but not language group (p = .82), was a significant predictor of excessive zeros. Similarly, the distributional part of the analysis revealed an effect of age (p < .001) but not of language group (p = .34), see Table 6. In other words, the noun-friendliness of Malay, in comprehension, did not differ between monolinguals and bilinguals.

As for production, age (p < .001) but not language group (p = .14), was a significant predictor of excessive zeros. In contrast, language group (p = .02) but not age (p = .17) was a significant predictor of the Malay verb-to-noun ratio, in production (see Table 7). Unexpectedly, the Malay of Malay-English bilinguals was richer in verbs than the Malay of Malay monolinguals, in production (see Table 7).

For Mandarin learners, the tests for the presence of zero-inflation were significant for production ($p < .001$) but not for comprehension ($p = 1$), hence a zero-inflation model was used

for production, whereas a linear model was used for comprehension. In comprehension, age ($p = .004$) but not language group ($p = .90$), was a significant predictor of the Mandarin verb-to-noun ratio (see Table 8). The verb-friendliness of Mandarin, in comprehension, did not differ between monolinguals and bilinguals.

In production, neither age ($p = .08$) nor language group ($p = .34$), were significant predictors of excessive zeros. Similarly, neither language group ($p = .06$) nor age ($p = .56$) predicted the Mandarin verb-to-noun ratio (see Table 9). As for comprehension, the verb-friendliness of Mandarin, in production, did not differ between monolinguals and bilinguals.

Q3 – How noun-friendly is Malay (in comparison to Mandarin and English)?

Our third question aimed at establishing the noun-friendliness of Malay, first in comparison to Mandarin, using the present sample of Malaysian data, then in comparison with both Mandarin and English, with data retrieved from WordBank. The common set of verbs and nouns was used when comparing the Malaysian sample, collected with the MCDI-M, with data retrieved from WordBank.

First, we compared the Malay verb-to-noun ratio of Malay monolinguals to that of the Mandarin of Mandarin monolinguals, in our sample. Due to its more complex morphological complexity, we expected that the Malay verb-to-noun ratio to be smaller than in Mandarin, in line with the proposal that richer morphological complexity of a lexical category slows down its learning (Gardner, 1982; Tardif, Shatz, & Naigles, 1997). The tests for the presence of zero-inflation were significant for both production and comprehension data ($p < .001$), hence zero-inflation models were used. In comprehension, age ($p = .043$) but not language group ($p = .997$),

was a significant predictor of excessive zeros – older participants were more likely to have verbs in their vocabulary. In contrast, language group ($p = .030$), but not age ($p = .215$), was a significant predictor of the verb-to-noun ratio (see Table 10). The Mandarin of Mandarin monolinguals was richer in verbs than the Malay of Malay monolinguals, in comprehension.

As for production, age ($p = .017$) but not language group ($p = .321$), was a significant predictor of excessive zeros. In contrast, neither language group ($p = .586$) nor age ($p = .252$) were significant predictors of the verb-to-noun ratio (see Table 11). The verb-to-noun ratio of Malay among monolinguals was comparable to that of the Mandarin of Mandarin monolinguals, in production.

Further analyses were conducted to evaluate the noun friendliness of Malay relative to both Mandarin and English (see Table 14). Given that our current sample did not include any English monolinguals, we supplemented the dataset with vocabulary data extracted from Wordbank, in both Mandarin and English. The test for the presence of zero-inflation was significant ($p < .001$), hence a zero-inflation model was used. The model revealed that age ($p < .001$) was a significant predictor of excessive zeros. Older participants were more likely to produce verbs.

The distributional part of the analysis (when vocabularies possess at least one verb) revealed an effect of age and that Malay verb-to-noun ratios were significantly larger than English ($p = .002$) but significantly lower than Mandarin ($p = .002$) (see Table 14 and Figure 3). Additional Tukey-adjusted pairwise comparison revealed that the Mandarin verb-to-noun ratios were significantly larger than English ($p < .001$). Mandarin and Malay are more verb-friendly than English, in production, while Malay was found to be less verb-friendly than Mandarin.

To examine whether Malay and Mandarin retained their relative verb-friendliness among bilinguals, we compared the Malay verb-to-noun ratio of Malay-English bilinguals to that of the Mandarin of Mandarin-English bilinguals. In comprehension, the model revealed that age (p = .021) but not language group (p = .996) was significant predictor of excessive zeros. Younger bilingual children were less likely to possess verbs in their vocabularies, yet. In contrast, both language group (p = .001) and age (p < .001) were significant predictors of the verb-to-noun ratio (see Table 12). The Mandarin of Mandarin bilinguals was richer in verbs than the Malay of Malay bilinguals, in comprehension – consistent with findings of their monolingual peers.

In production, the model revealed that age (p < .001) but not language group (p = .256) was a significant predictor of excessive zeros. Younger bilingual children were more likely not to possess verbs in their vocabularies yet. In contrast, language group (p = .006) but not age (p = .625) was a significant predictor of the verb-to-noun ratio (see Table 13). The Mandarin of Mandarin bilinguals was richer in verbs than the Malay of Malay bilinguals, in production – in contrast with findings of their monolingual peers, where Malay and Mandarin were similar in terms of noun-friendliness, but consistent with the findings of the comparisons made with Wordbank samples (see above).

Summary

In sum, our results suggest that in comprehension, but not in production, the English lexicon of Mandarin-English bilinguals is more verb-friendly than that of Malay-English bilinguals. This addressed the first question and suggests that extra-linguistic factors can modulate the noun bias. With the exception of Malay productive vocabularies, the noun bias does

not appear to differ between monolinguals and bilinguals, overall (addressing the second question). Finally, we found Malay to be more verb-friendly than English yet more noun-friendly than Mandarin for both bilingual participants and monolingual participants (with the exception of productive vocabularies among monolinguals in the MCDI-M sample), addressing the third question. Overall, the pattern of results suggests that extra-linguistic factors modulate the noun bias in a unidirectional manner – modulating English rather than the children's ethnic language.

Discussion

The present study looked into verb/noun distributions in the early lexicon of bilingually exposed infants and toddlers. Our first aim was to investigate whether what is known in the literature as a language-specific noun bias (in our case English) can be modulated by language-extrinsic factors. Our analysis with young children revealed that their English was less noun-friendly in comprehension (that is, the ratio of verbs to nouns was higher) among Mandarin-English bilinguals than it was among Malay-English bilinguals. This modulation of the noun bias cannot be attributed to language-intrinsic factors, as the focus is on the same language — English.

While our results suggest a modulation of the noun-friendliness of a language due to factors external to that language, we can only speculate about the mechanisms underlying such changes. A first interpretation is that the attentional patterns in parent-infant interactions modulate the structure of early lexicons. Chinese speakers tend to analyse visual scenes in a more holistic manner than English speakers, who tend to have focal attention towards individual objects (Nisbett, 2004; Nisbett & Miyamoto, 2005; Tardif et al., 1999; Waxman et

al., 2016). Holistic processing tends to reveal relations between objects, typically referred to with verbs, whereas focal attention emphasises individual objects, typically referred to with nouns. Following this stream of reasoning, infants raised in Chinese-ethnic families are exposed to attentional patterns favouring the acquisition of verbs in all languages that they are learning, including English.

Another potential explanation is that some features of a language (in our case the verb-friendliness) may bleed into the other language of a bilingual infant or toddler via processes of cross-language transfer. One could imagine that, in an immature system, languages are not properly differentiated yet, and that the structure of a language is heavily influenced by the structure of the other language being learnt by the bilingual infant (e.g., Volterra & Taeschner, 1978; Redlinger & Park, 1980; Meisel, 1989). As the ethnicity of families is confounded with the language environment (Mandarin-English children are raised in Chinese families while Malay-English children are raised in Malay families), one cannot firmly advocate between both explanations from our findings. Yet, much of the evidence in favour of a unitary language system hypothesis comes from observations of code-switching behaviour during childhood. This perspective is based on the *production* of speech, whereas our results suggest that the structure of the English lexicon changes in light of the other language infants and toddlers are exposed to, in *comprehension* too. The explanation that infants confuse both of their languages, bringing the verb/noun distributions of each language towards the other, is at odds with strong evidence that infants and toddlers discriminate languages from a very early age (e.g., Werker & Byers-Heinlein, 2008; Genesee, 1989; Meisel, 2001; Bosch & Sebastián- Gallés, 2003). Furthermore, and addressing the second question in the study, the Malay and the Mandarin

verb-to-noun ratios did not differ between monolinguals and bilinguals (with the exception of productive vocabularies in Malay), suggesting an asymmetry in the noun-bias modulation: while the English lexicon changes, the other language being learnt by children remains similar. In other words, it seems to suggest that transfer occurs more in the direction from the stronger/more established L1 (here, Mandarin or Malay) to the L2 (here, English) which functions as a *lingua franca*. As such, English, as the second language, is more susceptible of socio-cultural modulations than the other languages.

A third explanation is that the characteristics of parental input, in English, differ across groups. One could expect that the English of parents of English-Mandarin bilingual children contains more verbs that the English of parents of English-Malay bilingual children. Future work will aim at identifying the source of this modulation of the noun bias by comparing the word type and token produced by the parents during parent-child interaction with the verbs and nouns compositions of their children. A recent study has evaluated the verb to noun ratio of speech from parent-child interactions in a Singaporean bilingual population. Setoh, Cheng, Bornstein & Esposito (2021) found that most Singaporean Chinese mothers either used more verbs than nouns, or used similar number of verbs and nouns, in English and in Mandarin, thus suggesting that differences in the composition of parental input could be driving differences in the composition of their child's vocabulary. However, this finding falls short of explaining how Mandarin-English bilingual adults used more verbs in English than, say, Malaysian-English bilinguals adults in the first place. Thus, any of the above-mentioned explanations (or a combination thereof) may account for the emergence of differences in the English lexicons of young and adult bilinguals.

The focus on multilinguals exposed to languages having differing compositions – in terms of verbs and nouns – opens the door to further investigation into the roots of the noun bias, and into factors that may modulate this bias. The particular set of languages spoken in Malaysia (and Singapore) analysed in the present study, with Mandarin being verb-friendly, English being noun-friendly, and Malay in-between (as addressed by the third research question in the present manuscript), offers a unique opportunity to test competing theories about the origin of the noun bias.

In sum, our results suggest that the degree of noun-friendliness of a language can be influenced by factors external to that language. We argue that a likely explanation has the culture in which an infant is raised influencing the pattern of acquisition of verbs and nouns, possibly through differential attentional structures in her learning environment. Future research will investigate the link between attentional patterns in adults of different cultural communities and the verb/noun distributions in the lexicons of their children.

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Table 1. Word count for each word categories (common nouns and verbs) from the MCDI-M.

Word categories	
Animals	52
Vehicles	14
Toy	12
Food and Drink	42
Clothing	23
Body parts	26
Small household items	48
Furniture and rooms	27
Outside things	49
Action words	101

Table 2. Means, standard deviations and ranges of the Malay, English and Mandarin verbs and nouns count in comprehension, across the four language exposure groups (Malay monolinguals, Mandarin monolinguals, Malay & English bilinguals and Mandarin & English bilinguals).

Ethnicity	Exposure	Language	Category	*M*	*SD*	Min	Max
Malay	Malay only	Malay	Noun	165.22	84.38	4	293
			Verb	61.19	30.94	0	101
		Mandarin	Noun	0.06	0.40	0	4
			Verb	0.01	0.09	0	1
		English	Noun	16.44	54.45	0	293
			Verb	4.13	17.75	0	101
	Malay and English	Malay	Noun	160.09	94.50	0	293
			Verb	60.78	34.35	0	101
		Mandarin	Noun	0.06	0.55	0	8
			Verb	0.01	0.14	0	2
		English	Noun	68.51	92.17	0	293
			Verb	19.45	32.68	0	101
Chinese	Mandarin only	Malay	Noun	1.82	4.15	0	17
			Verb	0.23	0.61	0	2
		Mandarin	Noun	121.09	61.42	11	247
			Verb	54.81	23.21	5	94
		English	Noun	20.95	37.40	0	159
			Verb	1.18	3.11	0	11
	Mandarin and English	Malay	Noun	0.76	4.07	0	35
			Verb	0.18	0.70	0	5
		Mandarin	Noun	102.01	96.86	0	293
			Verb	45.62	38.07	0	102
		English	Noun	96.61	102.62	0	293
			Verb	35.31	38.95	0	101

Table 3. Means, standard deviations and ranges of the Malay, English and Mandarin verbs and nouns count in production, across the four language exposure groups (Malay monolinguals, Mandarin monolinguals, Malay & English bilinguals and Mandarin & English bilinguals).

Ethnicity	Exposure	Language	Category	*M*	*SD*	Min	Max
Malay	Malay only	Malay	Noun	99.66	83.50	0	281
			Verb	32.87	32.11	0	101
		Mandarin	Noun	0.06	0.40	0	4
			Verb	0.00	0.00	0	0
		English	Noun	5.94	32.60	0	274
			Verb	0.92	9.33	0	101
	Malay and English	Malay	Noun	87.79	91.24	0	293
			Verb	31.50	34.86	0	101
		Mandarin	Noun	0.05	0.48	0	7
			Verb	0.00	0.06	0	1
		English	Noun	34.72	61.21	0	282
			Verb	7.15	18.24	0	100
Chinese	Mandarin only	Malay	Noun	1.18	2.99	0	10
			Verb	0.23	0.61	0	2
		Mandarin	Noun	55.27	65.47	0	247
			Verb	16.33	18.87	0	56
		English	Noun	11.91	21.25	0	81
			Verb	0.64	1.56	0	6
	Mandarin and English	Malay	Noun	0.31	1.77	0	15
			Verb	0.05	0.27	0	2
		Mandarin	Noun	49.49	76.85	0	276
			Verb	21.68	31.89	0	98
		English	Noun	61.51	88.96	0	276
			Verb	18.88	31.93	0	100

Table 4. Estimates of the zero-inflated negative binomial model for the English verb-to-noun ratio between both language groups, Malay-English and Mandarin-English bilinguals, in comprehension.

Distributional part	Estimate	*SE*	*z*	*p*
Intercept	3.42	.13	26.86	< .001
Language group (Mandarin-English bilinguals used as ref.)	-.20	.08	-2.55	.011
Age (months)	-.01	.00	-1.44	.149
Zero-inflation part	**Estimate**	***SE***	***z***	***p***
Intercept	-2.87	.77	-3.72	< .001
Language group (Mandarin-English bilinguals used as ref.)	1.61	.62	-2.55	.009
Age	-.001	.02	-.08	.935

Table 5. Estimates of the zero-inflated negative binomial model for the English verb-to-noun ratio between both language groups, Malay-English and Mandarin-English bilinguals, in production.

Distributional part	Estimate	*SE*	*z*	*p*
Intercept	3.08	.24	12.71	< .001
Language group (Mandarin-English bilinguals used as ref.)	-.13	.11	-1.15	.252
Age (months)	-.001	.01	-.15	.885
Zero-inflation part	**Estimate**	***SE***	***z***	***p***
Intercept	.65	.75	-.87	.382
Language group (Mandarin-English bilinguals used as ref.)	1.51	.49	-3.07	.002
Age (months)	-.11	.03	-4.04	< .001

Table 6. Estimates of the zero-inflated negative binomial model for the Malay verb-to-noun ratio between both language groups, Malay monolinguals and Malay-English bilinguals, in comprehension.

Distributional part	Estimate	*SE*	*z*	*p*
Intercept	3.54	.06	63.95	< .001
Language group (Malay-English bilinguals used as ref.)	-.03	.03	-.95	.343
Age (months)	-.01	.00	-3.70	< .001
Zero-inflation part	**Estimate**	***SE***	***z***	***p***
Intercept	-.18	1.03	-.17	.862
Language group (Malay-English bilinguals used as ref.)	-.18	.82	-.22	.823
Age (months)	-.17	.06	-2.97	.003

Table 7. Estimates of the zero-inflated negative binomial model for the Malay verb-to-noun ratio between both language groups, Malay monolinguals and Malay-English bilinguals, in production.

Distributional part	Estimate	*SE*	*z*	*p*
Intercept	3.15	.10	30.79	< .001
Language group (Malay-English bilinguals used as ref.)	-.12	.05	-2.35	.019
Age (months)	.01	.004	1.38	.169
Zero-inflation part	**Estimate**	***SE***	***z***	***p***
Intercept	1.65	.71	2.31	.021
Language group (Malay-English bilinguals used as ref.)	-.58	.39	-1.48	.139
Age (months)	-.15	.03	-4.61	< .001

Table 8. Estimates of the linear model for the Mandarin verb-to-noun ratio between both language groups, Mandarin monolinguals and Mandarin-English bilinguals, in comprehension.

	Estimate	*SE*	*t*	*p*
Intercept	45.79	4.47	10.23	< .001
Language group (Mandarin-English bilinguals used as ref.)	-.38	3.05	-.12	.902
Age (months)	-.54	.18	-2.99	.004

Table 9. Estimates of the zero-inflated negative binomial model for the Mandarin verb-to-noun ratio between both language groups, Mandarin monolinguals and Mandarin-English bilinguals, in production.

Distributional part	Estimate	*SE*	*z*	*p*
Intercept	3.62	.26	14.04	< .001
Language group (Mandarin-English bilinguals used as ref.)	-.24	.13	-1.87	.061
Age (months)	-.01	.01	-.58	.563
Zero-inflation	Estimate	*SE*	*z*	*p*
Intercept	1.63	2.31	.71	.481
Language group (Mandarin-English bilinguals used as ref.)	.87	.90	.96	.337
Age (months)	-.18	.10	-1.77	.077

Table 10. Estimates of the zero-inflated negative binomial model for the verb-to-noun ratio between Malay in Malay monolinguals and Mandarin in Mandarin monolinguals, in comprehension.

Distributional part	Estimate	*SE*	*z*	*p*
Intercept	3.44	.11	30.68	< .001
Language group (Malay monolingual used as ref.)	.15	.07	2.17	.030
Age (months)	-.01	.004	-1.24	.215
Zero-inflation part	Estimate	*SE*	*z*	*p*
Intercept	9.31	5.66	1.65	.100
Language group (Malay monolingual used as ref.)	-15.43*	3798.86*	-.004	.997
Age (months)	-.75	.37	-2.03	.043

Table 11. Estimates of the zero-inflated negative binomial model for the difference of verb-to-noun ratio between Malay in Malay monolinguals and Mandarin in Mandarin monolinguals, in production.

Distributinal part	Estimate	*SE*	*z*	*p*
Intercept	3.04	.21	14.75	< .001
Language group (Malay monolingual used as ref.)	-.07	.12	-.55	.586
Age (months)	.01	.01	1.15	.252
Zero-inflation part	Estimate	*SE*	*z*	*p*
Intercept	1.95	1.57	1.24	.214
Language group (Malay monolingual used as ref.)	-.74	.74	-.99	.321
Age (months)	-.15	.06	-2.39	.017

Table 12. Estiamtes for the zero-inflated negative binomial model for the difference of verb-to-noun ratio between Malay in Malay-English bilinguals and Mandarin in Mandarin-English bilinguals, in comprehension.

Distributional part	Estimate	*SE*	*z*	*p*
Intercept	3.59	.06	62.37	< .001
Language group (Malay-English bilinguals used as ref.)	.14	.04	3.23	.001
Age (months)	-.01	.002	-4.36	< .001
Zero-inflation part	**Estimate**	***SE***	***z***	***p***
Intercept	-.82	1.10	-.74	.458
Language group (Malay-English bilinguals used as ref.)	-17.01*	3264.22*	-.01	.996
Age (months)	-.13	.06	-2.31	.021

* Large estimate and *SE* due to lack of zero inflation in the Mandarin-English bilingual groups.

Table 13. Estimates of the zero-inflated negative binomial model for the difference of verb-to-noun ratio between Malay in Malay-English bilinguals and Mandarin in Mandarin-English bilinguals, in production.

Distributional part	Estimate	*SE*	*z*	*p*
Intercept	3.42	.12	27.67	< .001
Language group (Malay-English bilinguals used as ref.)	.18	.06	2.75	.006
Age (months)	-.001	.004	-.49	.625
Zero-inflation part	**Estimate**	***SE***	***z***	***p***
Intercept	-.96	.99	-.97	.331

Language group (Malay-English bilinguals used as ref.)	-.73	.64	-1.14	.256
Age (months)	-.15	.03	-4.31	< .001

Table 14. Estimates of the zero-inflated negative binomial model for the verb-to-noun ratio between Malay in Malay monolinguals, Mandarin in Mandarin (Beijing) monolinguals from Wordbank and English in American English monolinguals from Wordbank, in production.

Distributional part	Estimate	*SE*	*z*	*p*
Intercept (Malay Monolingual)	3.22	.12	26.04	< .001
Mandarin (Beijing)	.15	.05	3.02	.002
English (American)	-.17	.05	-3.14	.002
Age (months)	.02	.005	4.97	< .001
Zero-inflation part	Estimate	*SE*	*z*	*p*
Intercept (Malay Monolingual)	2.67	1.71	1.56	.119
Mandarin (Beijing)	-18.42*	3356.68*	-.01	.995
English (American)	-.91	.64	-1.43	.153
Age (months)	-.22	.08	-2.72	.007

* Large estimate and *SE* due to lack of zero inflation in the Mandarin groups.

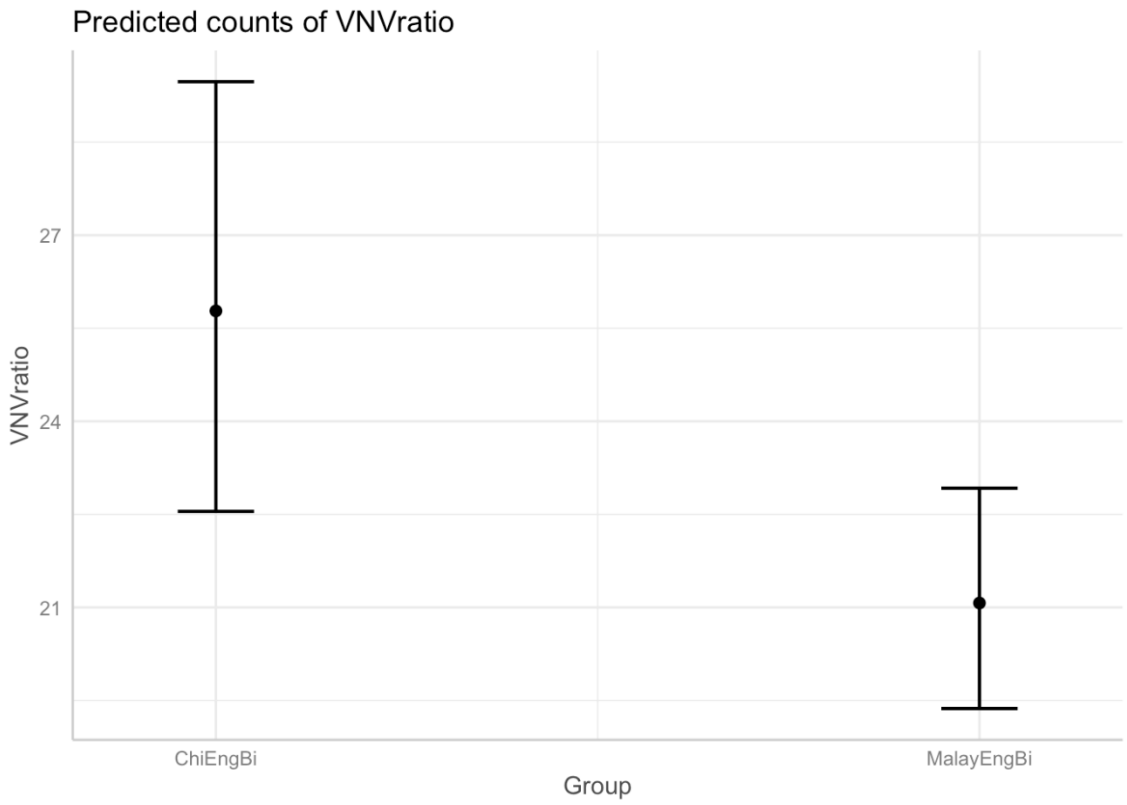

Figure 1. Predicted English verb-to-noun percentage ratios in comprehension for Malay-English and Mandarin-English bilingual children using zero-inflation negative binomial model, by group. Note that the reporting of sample means were replaced with predicted means stemming from the model to account for the other factors in the model.

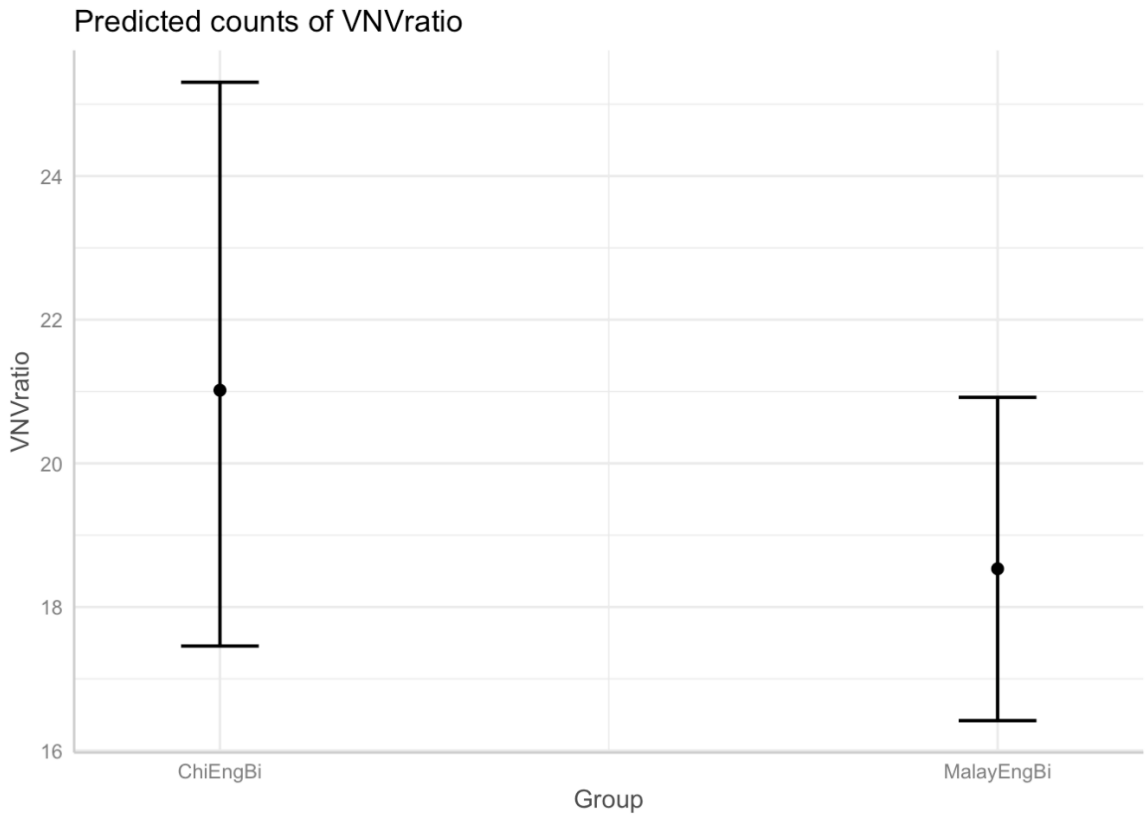

Figure 2. Predicted English verb-to-noun percentage ratios in production for Malay-English and Mandarin-English bilingual children using zero-inflation negative binomial model, by group. Note that the reporting of sample means were replaced with predicted means stemming from the model to account for the other factors in the model.

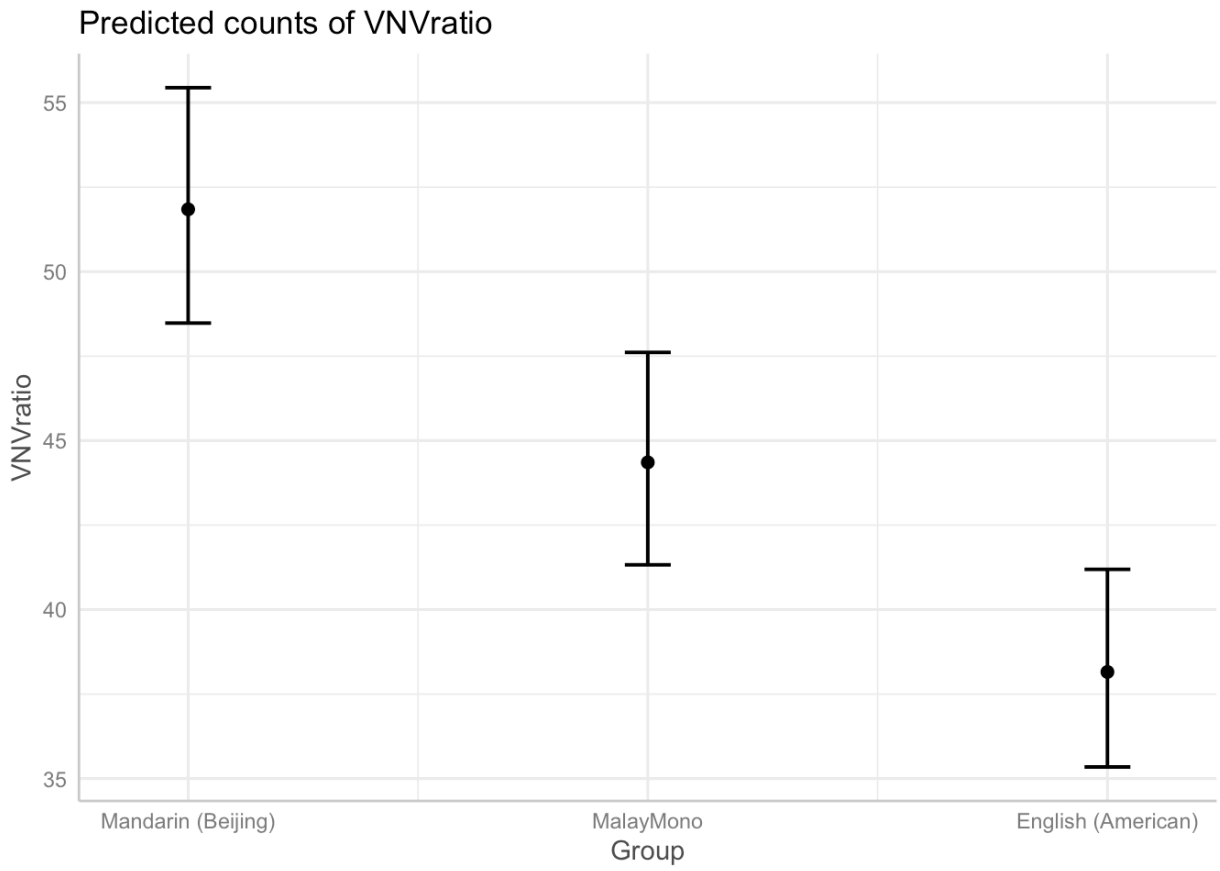

Figure 3. Predicted English verb-to-noun percentage ratios (and .95 confidence intervals) for English (American), Malay for Malay monolinguals and Mandarin for Mandarin (Beijing) children using zero-inflation negative binomial model, in production. The reporting of sample means were replaced with predicted means stemming from the model to account for the other factors in the model. Note that the verb-noun ratios are higher here due to the restricted set of common words used to allow direct comparisons with data from WordBank.