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# The impact of child-directed language on children's lexical development

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## Abstract

This study investigated (1) whether and how English caregivers adjust their speech (i.e., mean length of utterances, lexical diversity, lexical sophistication, sentence types, and deixis) according to different contexts, children's knowledge, and age, and (2) which aspects of parental speech input predict children's immediate learning of novel words as well as their vocabulary size. We studied a semi-naturalistic corpus, in which English caregivers talked to their children (3-4 years old) about toys that were present or absent, and known or unknown to the children. We found that caregivers flexibly adjusted various aspects of their speech to maintain an informative and engaging learning environment. Furthermore, we found that rich lexicon and yes-no questions predict better immediate word learning, whereas caregivers' lexical diversity, lexical frequency, the use of Yes-No questions are related to children's general vocabulary size. In conclusion, higher quality of caregivers' language predicts better immediate word learning and vocabulary size.

**Keywords:** child-directed language; word learning; language input; lexical sophistication; lexical diversity; yes-no questions

## Introduction

Child-directed language (CDL) is typically clear, brief and characterized by hyper-articulation (Fernald, 1984), features that can facilitate children's language learning (e.g., Furrow, Nelson & Benedict, 1979; Hoff & Naigles, 2002; Huttenlocher, Haight, Bryk, Seltzer & Lyons, 1991).

Considering the role of caregiver input, different views have been proposed. One of these proposals, which can be referred to as "*the data-providing view of the input*", argues that learning words is a data-crunching process and that the quality of the input is important (Anderson et al., 2021; Hoff & Naigles, 2002). Under this view, at least two properties of CDL are argued to benefit lexical development: lexical richness and syntactic complexity.

In terms of lexical richness, since the meaning of a novel word can often be inferred from the rest of the utterance, the use of different words when talking about a new referent by the caregivers may have a positive impact supporting children in developing hypotheses on the meaning of the new word. It has been shown that lexical richness, measured by the number of word types in the input, predicted the subsequent productive vocabulary of 24 months old children

(Hoff & Naigles, 2002). Rowe (2008) also reported that lexically rich CDL at 2;6 positively predicted children's vocabulary comprehension score at 3;6. Moreover, it has also been found that measures of sentence structure and syntax of CDL (parental mean length of utterance (MLU)), were positively related to children's comprehension and production vocabulary (Bornstein, Haynes & Painter, 1998; Hoff & Naigles, 2002; Rowe, 2008). There are two possible explanations for the facilitatory effect of longer MLU. One is through syntactic bootstrapping, which argues that the use of complex syntactic structure gives cues to the meaning of novel words (e.g., Naigles, 1990). Alternatively, one can argue that longer utterances provide more semantic information than shorter ones and that it is the additional information that helps children build lexicon-semantic representations for novel words (Hoff & Naigles, 2002). One additional property that may influence lexical development is lexical sophistication (often indicated by the word frequency) of CDL. For instance, Rowe (2012) found that English caregivers' use of sophisticated vocabulary with toddlers explained later vocabulary ability. Similarly, preschool teachers' use of low-frequency vocabulary during free play predicted fourth-grade reading comprehension and word recognition (Dickinson & Porche, 2011).

Another influential view, that can be referred to as "*the social-pragmatic view*" claims that conversational experience not only provides linguistic data to the learner, but also helps children discern caregivers' communicative intention through the mutual engagement or joint attention even when children do not understand the language. Hence, CDL serves as one way of establishing mutual engagement between the dyads, aiding the mapping between sound and meaning (Tomasello & Todd, 1983).

Evidence for this view comes primarily from analyses of sentence-types used in CDL and the use of deixis in parental language. Studies that have examined different sentence types in parental input have found that the proportion of directives (i.e., imperative sentences) negatively correlates with vocabulary comprehension score, while the proportion of Wh-questions and Yes/No questions positively correlates (Rowe, 2008). This is because the use of directive language indicates caregivers' intention of controlling the children or redirecting their attention, whereas questions eliciting conversations reveal their purpose of interacting with the

children. Therefore, a better mutual engagement might benefit language development (Hoff-Ginsberg, 1991). Furthermore, it was found that declaratives occurred more in adult-directed language (ADL) than CDL, while fragmented sentences, briefer than declaratives, occurred more in CDL than ADL (Newport et al., 1997). Whether sentence types such as fragments facilitate or hinder word acquisition is unclear. As for deixis, the claim is that its use is likely to establish joint attention (Levinson, 2004), however, the extent to which it can help word acquisition also remains unclear.

In this study, we comprehensively characterize the language used by caregivers to their children considering measures taken from both the data-providing and the socio-pragmatic views. We use data from the Ecolang corpus (Vigliocco et al., unpublished). Caregivers were recorded while talking about a set of objects (provided by the experiments) which contained both known and unknown toys to the child. We introduced this manipulation as cases in which the child is unfamiliar with the object and its label are clear learning episodes. Moreover, we manipulated whether the objects talked about were present or absent (displaced language). This latter manipulation captures the observation that a large part of caregivers' communication is about objects and events absent from the physical setting (Veneziano, 2001). Crucially, very little is known about how caregivers adjust their language to ensure that children can learn in these more complex, displaced contexts. We focus on children aged 3-4 because this is a time of vocabulary growth in which communication about displaced referents is present. Immediate learning was assessed with a recognition task carried out right after the recording session. Children's general vocabulary was also assessed at the time of recording.

The specific research questions addressed are: (1) Do caregivers adjust their speech according to the (situated or displaced) context, children's knowledge of what is talked about, and children's age? (2) Does variation in any aspect of parental speech predict measures of immediate learning (recognition of unknown words) and vocabulary size?

For the displaced context, caregivers may adopt two possible strategies to facilitate children's word learning. On the one hand, since it is both cognitively demanding for the children to retrieve the referents of the labels and is also hard for them to maintain their attention when there is no toy, caregivers may simplify their language, and adopt a more engaging interaction style. It could be that caregivers will use shorter MLU, and more fragmented sentences, as well as more frequent words to reduce processing difficulty. They may also use more Yes/No questions and Wh-questions to hold children's attention. They should also use more deixis when a toy is present given that these indexical expressions are more ambiguous when there is no referent. On the other hand, without the visual aid of objects, caregivers have to rely more on language to convey information in the displaced context, thus using longer sentences, richer and sophisticated vocabularies and also more declaratives.

English caregivers also slow down their speaking rate (Han, de Jong & Kager, 2021; Shi, Gu, Grzyb & Vigliocco, 2020) and produce more representational gestures (Vigliocco et al., 2019) when talking about unknown objects. However, we do not know whether and how the caregivers' language features we are focusing on here may adjust to facilitate learning. One possibility is that caregivers may use longer utterances, richer vocabulary, and more declaratives to give a detailed description about the unknown toys to aid the learning of labels and the corresponding concepts. In addition, they may also use more deixis to establish shared attention on the unknown toys. Alternatively, since unknown toys are likely to impose processing difficulties on children, caregivers may instead use shorter utterances, more fragmented sentences, and simpler vocabularies. It is unclear how caregivers will ultimately reconcile informativeness and simplicity in teaching children about unknown objects. For known toys, however, few learning episodes of labels are involved. Hence, they may use more imperatives that ask the children to perform an action upon the toys, as well as questions that elicit children to talk about the toys.

Children's age will also affect caregivers' language. It has been found that the child-directed prosody decreased with the growth of children's age from 18 months to 24 months (e.g., Han, 2019). However, there are only a few studies focusing on the adjustment of speech features. Newport and colleagues (1997) found that parents' MLU and the use of declaratives increased with children's MLU, while imperatives decreased. How other speech features change according to children's age awaits investigation.

## Method

### Participants

Thirty-one caregiver-child dyads from the Ecolang corpus (Vigliocco et al., unpublished) were included in the study. All the participants were native English speakers. Children's age ranged from 36 to 52 months old (mean=42.13 months old,  $SD=4.37$  months). A Kolmogorov-Smirnov test indicated that age followed a normal distribution,  $D=.15$ ,  $p=.43$ . The study obtained ethical approval from UCL. Below the materials and procedure of the Ecolang corpus data collection and child vocabulary measurements were described.

### Materials

The stimuli used in the caregiver-child interaction were taken from four categories of toys (animals, tools, foods, and musical instruments). For each dyad, six toys per category were included in the experiment (24 toys in total). Half of the six toys from each category were known, and the other half were unknown to the child. Children's familiarity with the toys (labels and concepts) was determined by caregivers filling a checklist before the experimental days.

To test children's vocabulary size, the BPVS3 (British Picture Vocabulary Scale 3rd edition, Dunn et al., 2009) were administered. Additionally, children performed a recognition task via E-prime. There were 24 critical trials for unknown

words (each target word presented twice). In each target trial, two unknown pictures were presented, followed by a pre-recorded question such as “Can you help me to find the [papaya], where is the [papaya]?”. The child needed to point to the picture that matched the word they heard.

## Procedure

Children did the BPVS3 test prior to the interaction. For the interaction session, the caregiver and child sat at 90 degrees from each other around a table. Caregivers’ speech was recorded using a clip-on microphone via Audacity.

Caregivers were instructed to talk about the toys in a natural way, both with the toys being absent or present but in two different sessions. The sequence of toy categories, as well as the present-first or absent-first sessions within each category were counterbalanced. In the present condition, the experimenter brought six toys from one category to the dyad. Then the dyad interacted with the toys for about 3-4 minutes as one session. In the absent condition, the dyad either talked about the toys that had already been taken away or were about to come for 3-4 minutes as another session. Caregivers were provided with the labels of the toys as a reminder. This process repeated for all four categories (two sessions per category), so there were 8 sessions for each dyad lasting about 25-35 minutes. After the interaction, children performed the unknown word recognition task.

## Annotation and measurements

**Caregivers’ speech** Caregiver’s speech was manually transcribed by utterance using Praat (Boersma & Weenink, 2019). Each utterance was coded for presence (present or absent) and the familiarity of an utterance was coded according to its topic (known or unknown). Utterances whose topics that were not about the toys were excluded.

To evaluate the data-providing view we measured: (1) MLU, (2) lexical richness, (3) lexical sophistication. *MLU* served as an index for syntactic complexity and richness of information. Note that we did not transcribe or analyze at the level of morphemes, but by calculating the average number of words per utterance as done in Dickinson and Porche (2011). *Lexical diversity* was measured by *vocd-D* which is less biased than the type-token ratio since it controls for the amount of talk produced (Malvern, Richards, Chipere & Duran, 2004). *Lexical sophistication*, which indicated whether the caregiver was more likely to use frequent words or infrequent content words, was measured by British National Corpus (BNC Consortium) using an automatic text analysis tool, TAALES 2.0 (Kyle, Crossley & Berger, 2018). We used this measurement as it could provide the word frequency of all content words automatically.

To assess the social-pragmatic perspective of parental input we measured sentence types and the use of deixis. For the classification of sentence types, utterances that belonged to one of the following categories were excluded from the analysis because they were not the focus of the current paper: onomatopoeia, isolated label name, social routine (e.g., thank you, goodbye), interjections (e.g., hmm, yeah), exclamations

(e.g., good!), unclear utterances and incomplete utterances. The rest of the utterances were classified into five categories: declaratives, imperatives, Wh-questions, Yes/No questions, and fragmented sentences (e.g., looks like an orange). Deixis was coded by the use of “that”, “this”, “it”, etc.

**Outcome measures** (1) Recognition scores were calculated by computing the number of trials that children correctly identified the labels out of all target trials. (2) We used the raw score for BPVS3 at the time of recording as a measure of children’s general vocabulary size.

## Data Analysis

In total, we obtained 17072 utterances (Present Known: 4059, Present Unknown: 5826, Absent Known: 3411, Absent Unknown: 3776). For the dependent variables of MLU, lexical diversity and lexical sophistication, we used linear mixed effect models in the R environment (R Core Team, 2020). The centered fixed effects were the presence (present or absent of the toys), familiarity (known or unknown), and child’s age in months, as well as their interaction. Participants were included as a random intercept. We did not include the toy names as a random intercept as in many utterances caregivers may talk about a toy without using the label. Thus, categories of toys were entered as a control variable. For the binary dependent variable deixis, we used mixed logit models, with the same fixed effects, random effects and control variable.

Additionally, to examine whether caregivers employed different sentence types according to contexts and children’s word familiarity, we fitted multinomial logit models to panel data in Stata. After excluding the utterances which belonged to sentence types that were not the focus of the current paper, we ended up with 12645 utterances. The dependent variables were five categories (Declaratives: 5171, Imperatives: 659, Wh-questions: 2776, Yes/No questions: 2839, fragments: 1200). The independent variables were presence (present/absent), familiarity (known/unknown), and the interaction between presence and familiarity. Age was added as a control variable.

Finally, using all the above predictors as independent variables, we performed logistic regressions for word recognition results, and linear regressions for BPVS3 scores in R, with the total number of utterances entered as an additional control variable.

## Results

Figure 1 and Figure 2 provide an overview of the results of all measurements from the data-providing view and the social-pragmatic view, and the details of each view are further reported below (for space reason, figures are grouped according to different analyses).

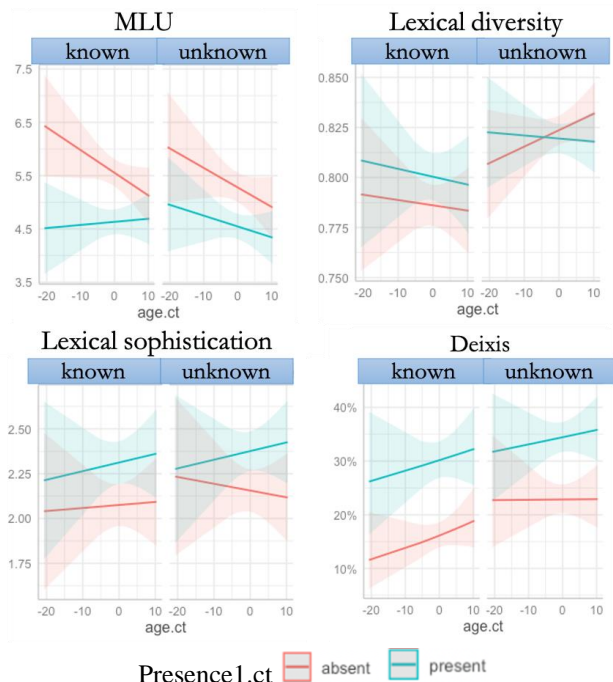


Figure 1: Predicted results of MLU, lexical diversity, lexical sophistication (data-providing view), and deixis (social-pragmatic view) as a function of toys presence, familiarity to children, and children's age.

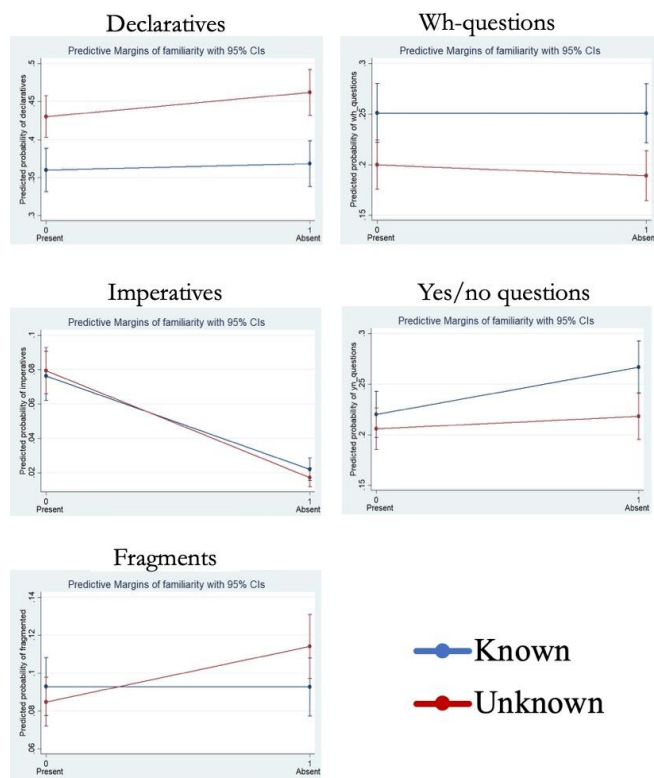


Figure 2: The proportion of the five sentence types as a function of toys presence and familiarity to children (social-pragmatic view).

## Data-providing view measurements

*MLU* was shorter when the toys were present ( $M=4.58$ ) than absent ( $M=5.38$ ) ( $\beta=-.82$ ,  $p<.001$ , 95%CI [-.994, -.637]). Neither the effect of familiarity nor any interaction term was significant.

*Lexical diversity* was higher ( $M=.82$ ) when the toys were unknown than known ( $M=.80$ ) ( $\beta=.027$ ,  $p<.001$ , 95%CI [.018, .036]), but there was not a main effect of presence. A significant interaction between familiarity and presence ( $\beta=-.018$ ,  $p=.008$ , 95%CI [-.03, -.006]) showed that when the toys were known, lexical diversity was higher when toys were present than when they were absent.

*Lexical sophistication* was lower when toys were absent ( $M=2.13$ ) than the present ( $M=2.26$ ), indicating that words were less sophisticated when the toys were absent ( $\beta=-.228$ ,  $p<.001$ , 95%CI [.152, .304]). The effect of familiarity and all interaction terms were not significant.

Age was not significant in all the above analyses.

## Social-pragmatic view measurements (five sentence types and deixis)

*Declaratives* were used more for unknown (33.2%) than known (26.5%) toys, regardless of presence (absent  $p<.001$ , 95%CI [.047, .093], present  $p<.001$ , 95%CI [.068, .119]). With a comparison of presence, caregivers used more declaratives in the absent context only for the unknown toys. Additionally, caregivers used fewer declaratives for older children ( $p=.003$ , 95%CI [-.011, -.002]).

*Imperatives* were used significantly more in the present (5.6%) than displaced context (1.4%), regardless of the familiarity of the toys (known:  $p<.001$ , 95%CI [-.075, -.05]; unknown:  $p<.001$ , 95%CI [-.068, -.041]). But the effect of age was not significant.

*Wh-questions* were used more when the toys were known in both present ( $p<.001$ , 95%CI [-.071, -.031]) and absent conditions ( $p<.001$ , 95%CI [-.084, -.039]), and its usage increased with age ( $p=.039$ , 95%CI [.0002, .009]).

*Yes/No questions* were used more in absent (18.4%) than present (15.3%) condition, and with known (17.8%) than unknown (15.7%) toys. There was a significant interaction between presence and familiarity ( $p=.025$ , 95%CI [-.064, -.004]), indicating that Yes-No questions were used most when the toys were known to the child in the displaced context. Their use did not vary with age.

*Fragmented sentences* were used more in the absent (8.2%) than the present (6.2%) condition. Interaction effect was also significant ( $p=.007$ , 95%CI [.008, .051]). They were used the most when the toys were unknown in the displaced context. The effect of age was not significant.

*Deixis* was used significantly more when the toys were present (33.2%) and when the toys were unknown (21.2%). There was an interaction between presence and familiarity ( $\beta=-.24$ ,  $p=.04$ , 95%CI [-.46, -.01]), revealing that deixis was used mostly for unknown toys in the present condition. Age was not significant.

## What measures predict immediate learning and vocabulary size?

For the analysis of immediate learning (using the unknown word recognition scores as a dependent variable), we first entered all measures as independent variables, including MLU, lexical richness, lexical sophistication, sentence types, deixis, number of utterances and child's age into the same regression model, and then dropped the non-significant measures one by one. The full model was not better fitting than the simplified one ( $\chi^2=2.56$ ,  $p=.92$ ), but instead had a higher AIC (153.9 vs. 142.4), so we used the simpler one as the final model. As shown in Table 1, lexical diversity ( $\beta=39.617$ ,  $p=.0004$ ) and Yes/No questions ( $\beta=3.614$ ,  $p=.017$ ) were positively correlated with higher word recognition scores.

Similarly, for BPVS3 scores, we first entered all measures as independent variables (AIC=244.89), after a model comparison, we ended up with a model with the independent variables of MLU, lexical diversity, lexical sophistication, Yes-No questions, fragments, deixis and age, with an R-squared of 0.63 and an adjusted R-squared of 0.52 (AIC=234.72). The results showed that lexical diversity ( $\beta=720.9$ ,  $p=.0019$ ), lexical sophistication ( $\beta=27.1$ ,  $p=.014$ ), Yes/No questions ( $\beta=82.9$ ,  $p=.0027$ ) were positively correlated with a larger vocabulary size. Additionally, the fragmented sentences were marginally positively related to larger vocabulary size ( $\beta=88.9$ ,  $p=.08$ ) whereas MLU had a negative correlation ( $\beta=-8.8$ ,  $p=.048$ ).

Table 1: Summary of results for the analysis on unknown word recognition and BPVS3.

Predictors	Recognition	Predictors	BPVS3
MLU	-.35 .	MLU	-8.8 *
Lexical diversity	39.62 ***	Lexical diversity	720.9 **
Wh-questions	2.62 .	Lexical sophistication	27.1 *
Yes/No questions	3.61 *	Yes/No questions	82.9 **
		Fragments	88.9 .
		Deixis	38.92
		Age	.66

\*\*\* $p<.001$ , \*\* $p<.01$ , \* $p<.05$ , . $p<.1$

## Discussion

This study investigated how English caregivers adjusted their speech according to the communicative contexts, children's familiarity with objects being talked about, and children's age. We also examined whether variation in the speech characteristics of caregivers predicted variation in children's immediate word learning and general vocabulary size.

Caregivers' speech was analyzed from two perspectives. From the data-providing perspectives, we measured caregivers' MLU, lexical diversity and lexical sophistication. Considering the accessibility of the referents, we found that

caregivers used longer utterances when the toys were absent, to provide more verbal information to compensate for the lack of visual stimuli. Caregivers were also less likely to use infrequent words in the displaced context. This suggested that when the context made it more difficult for children to retrieve the referents, caregivers tried to reduce such difficulty by using less sophisticated language.

In terms of familiarity with the toys, caregivers used more different words for unknown toys, thus providing more semantic information about objects that the children did not know (to be learnt). The effect of age was not significant for any of the data providing measurements, which may be due to the small age range of the current sample or the age of 3-4 years old is not particularly sensitive or too old to test these measurements as the children already have relatively good language ability (e.g., can actively talk).

From the social-pragmatic perspective, we measured the sentence types and the use of deixis. Not surprisingly, we found more descriptions when the toys were absent, and more imperatives when the toys were present. Yes/No questions were used the most in the displaced context for known toys which may index caregivers' attempt to sustain children's attention in this less entertaining condition. Fragmented sentences were most common for displaced unknown referents which may be related to the greater cognitive load of this condition. Finally, deixis was used more in the present condition, in line with a role for deixis in establishing joint attention (Levinson, 2004).

Considering the effect of children's knowledge on parental speech, we found that declaratives were used more for unknown toys, while Wh-questions were used more for known toys. Interestingly, caregivers' use of declaratives decreased with age, while Wh-questions increased with age.

We then looked at which of these different characteristics predicted immediate learning of labels and vocabulary size. For immediate learning of the label, we found that Yes/No questions and lexical diversity were significant predictors. Yes/No question, fragmented sentences, along with a richer, and more sophisticated vocabulary were positively related to vocabulary size whereas MLU was negatively related to vocabulary size.

Along with Hoff and Naigles (2002)'s study, our study is one of the few studies that have investigated the effect of both data-providing and social-pragmatic functions on children's lexical development. In contrast to Hoff and Naigles who found that data-providing but not social-pragmatic function predicted children's lexical development, our results showed that measures taken from both views predicted lexical development. Such differences may not only be due to the distinct measurements of vocabulary size (child's spontaneous speech production vs. our unknown word recognition and BPVS tests), but also partially be due to the input measurement such as the different categorization of sentence types. In Hoff and Naigles (2002)'s study, all questions were treated as one type whereas we had sub-categorized question sentences into Wh- and Yes/No questions. The results that caregivers' Yes/No questions were

correlated with both immediate and general word learning suggest that they may serve a particular function in establishing joint attention, and probably being high-quality input. Our study thus provides some insight into the theoretical question of whether the quantity or quality of parental input facilitates word learning (e.g., Anderson et al., 2021; Dickinson & Porche, 2011; Rowe, 2012; Shneidman et al., 2013). An increasing number of studies have shown that input quality plays a distinctive role in children's lexical development, after controlling for the amount of input (e.g., Cartmill et al., 2013). Our evidence supports this view that quality (i.e., the use of Yes/No questions, lexical diversity) benefitted immediate word learning and general lexical development. By contrast, the total number of utterances (an index of quantity), did not have a significant effect on a child's vocabulary size.

Nevertheless, the lack of an effect of the number of utterances on word learning does not imply that quantity is not important or predictive of vocabulary growth at this age. Actually, quantity and quality are two intertwined aspects of parental input that are hard to disentangle from each other. Measures like utterance numbers provide a first approximation about the number of information units and learning opportunities available to the child. Plausibly, a large amount of input makes high-quality input more likely to occur. Additionally, the observed benefit of lexical richness on immediate and general word learning should be interpreted as a benefit of not only lexically varied input but also of a large amount of such input (see Hoff & Naigles, 2002).

A meta-analysis linking quality and quantity of parental linguistic input to child language skills suggests that quantity of language may help to initiate the language learning process, but input quality would become increasingly important once children have the foundational capacity to benefit from such speech, as well as becoming more important when children are older (Anderson et al., 2021).

In contrast to previous research showing that MLU was positively related to children's comprehension and production vocabulary, we found an unpredicted negative correlation between children's vocabulary size and parental MLU and a positive correlation between vocabulary size and use of fragmented sentences. Given that the longest MLU and fragments were produced in the toys absent condition, such findings on correlations could be interpreted as using complex utterances may not be beneficial to the very young language learner (Rowe & Snow, 2020), especially in the displaced context.

Alternatively, caregivers likely adapt to children such that children with smaller vocabulary size modulated caregivers to use a longer MLU and fewer fragments. Similarly, for other positive correlations found in the current study, the possibility of producing higher quality CDL may be a response to children's language sophistication, and not necessarily only a cause of it, given that our word learning and vocabulary size measurements were both tested at the concurrent time of the experiment. This interpretation

supports the notion that what constitutes optimal input may change in accordance with children's maturing language abilities (Jones & Rowland, 2017). Future studies should examine further correlations between these input features and children's vocabulary longitudinally.

Furthermore, note that input quality should not be restricted only to speech, as past research (including Cartmill et al., 2013) have taken a multimodal view on caregivers' input showing that child-directed prosody (e.g., Raneri, 2015; Shi et al., 2020); actions on objects (Gogate et al., 2000) and gestures (e.g., McGregor, 2008; Vigliocco et al., 2019) facilitate word learning.

## Conclusion

The current research firstly addressed the question of whether English CDL is adaptive to the context, children's knowledge and age. Much of the previous research focused on prosody or multimodal cues of CDL in examining this question, whereas our study might be the first to approach this question considering features of the spoken input. We found that English caregivers adjusted their speech as predicted both by the data-providing and the social-pragmatic views. In displaced contexts, caregivers used longer utterances to provide more information, less sophisticated vocabulary and fragmented sentences to reduce processing difficulty, and more Yes/No questions to maintain children's attention. With unknown toys, caregivers used richer vocabulary to provide more semantic cues, and they provided more descriptions. In contrast, for known toys, caregivers asked more questions. With increased age, caregivers may give more autonomy for children to express themselves. All these findings suggested that caregivers were aware of children's cognitive load and their knowledge, thus adjusted their speech to establish a more informative and effective learning environment. Furthermore, we found that quality of parental input was important for word learning. Our study provided insight into the adaptiveness of English caregivers' speech and the facilitating aspect of it on lexical development.

More detailed results of the analysis of sentence types in multinomial logit models to panel data can be found in OSF link <https://osf.io/tvhwf/>.

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