Infant contributions to joint attention predict vocabulary development

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Abstract

Joint attention has long been accepted as constituting a privileged circumstance in which word learning prospers. Consequently research has investigated the role that maternal responsiveness to infant attention plays in predicting language outcomes. However there has been a recent expansion in research implicating similar predictive effects from individual differences in infant behaviours. Emerging from the foundations of such work comes an interesting question: do the relative contributions of the mother and infant to joint attention episodes impact upon language learning? In an attempt to address this, two joint attention behaviours were assessed as predictors of vocabulary attainment (as measured by OCDI Production Scores). These predictors were: mothers encouraging attention to an object given their infant was already attending to an object (maternal follow-in); and infants looking to an object given their mothers encouragement of attention to an object (infant follow-in). In a sample of 14-month old children (N=36) we compared the predictive power of these maternal and infant follow-in variables on concurrent and later language performance. Results using Growth Curve Analysis provided evidence that while both maternal follow-in and infant follow-in variables contributed to production scores, infant follow-in was a stronger predictor. Consequently it does appear to matter whose final contribution establishes joint attention episodes. Infants who more often follow-in into their mothers' encouragement of attention have larger, and faster growing vocabularies between 14 and 18-months of age.

Keywords: vocabulary, maternal responsiveness, joint attention, growth curve modelling

Introduction

An extensive body of research has identified several fundamental influences on word learning during infancy and early childhood. Some influences are broad predictors of language ability, such as maternal education and frequency of story reading in the home (Brooks & Meltzoff, 2008; Crain-Thorenson & Dale, 1992). Other influences on language ability are local and specific, and as a result allow causal hypotheses about specific processes through which words are learned, such as joint attention (eg; Carpenter, Nagell & Tomasello, 1998;). Joint attention refers to a situation in which two people share a common point of reference, such as when a mother and child both look at a toy and periodically look to one another as well, while at the same time the mother describes the toy (Mundy & Newell, 2007). In such situations, joint attention is thought to help children identify relations between words and their referents, and in so doing, increase word learning (Baldwin, 1991; 1993; Brooks & Meltzoff, 2008). Joint attention thus depends on adult and infant behaviours, and the conjunction of the two supports word learning (Smith, Yu & Pereira, 2011).

Several studies of naturalistic parent-infant interactions have demonstrated that parents differ in how they interact with infants, and these differences influence word learning. These differences include the frequency of utterances, use of prescriptives, and choice of object reference whilst interacting with their infants (Akhtar, Dunham & Dunham, 1991; Masur, Flynn & Eichorst, 2005; Tomasello & Farrar, 1986). Perhaps most importantly, the results of a number of longitudinal studies indicate that caregivers' sensitivity and responsiveness to their infants' focus of attention during parent-infant interactions predicts the timing of early linguistic milestones and vocabulary growth rate (e.g., Carpenter et al., 1998; Tamis-LeMonda, Bornstein & Baumwell, 2001). This evidence suggests that caregivers are responsible for joint attention episodes: when caregivers notice their infants' focus of attention and join in, joint attention is established, and as a result, word learning is supported.

Other studies have identified robust infant characteristics that influence word learning, such as infant attentional abilities or attention style. For example, Tamis-LeMonda and Bornstein (1989) reported that 5-month-olds who habituated to a visual stimulus more quickly also had larger receptive vocabularies at 13 months. Dixon and Smith replicated this finding and demonstrated that infant temperament moderates the relation between attention and vocabulary size (Dixon & Smith, 2008). The influence of infant attention on vocabulary size is presumed to function via joint attention, and indeed, individual differences between infants on experimental measures of gaze following predict later language (Brooks & Meltzoff, 2005; 2008). Until recently, however, the hypothesised relation between infant joint attention and word learning was presumed through global longitudinal relations rather than observations of local, specific relations. Recent work using microanalytic techniques for investigating joint attention and word learning has given insight into both infant and maternal contributions. Infants holding an object named by the adult, the size of the object in the infant's view, and the stability of head movements during naming are predictive of word learning (Yu, Xu & Zhu, 2011). Additionally parents' holding the object being named is only predictive of word learning when in doing so they attract their infants' attention (Yu et al., 2011). In similar micro-analytic studies of children's eye movements during word learning, systematic, selective and sustained attentional shifts have been labelled the "critical factor" (Smith & Yu, in press; Yu & Smith, 2012).

Our aim was to build on the studies of Yu et al., and Yu & Smith by examining both maternal and infant contributions to joint attention, and to examine the significance of those contributions for word learning at a global, rather than local level. A lot is known about infant and maternal behaviours during constrained learning tasks but much less about their micro-level behaviours in real time such as during free play (Yu et al., 2011). On a general environmental level maternal reponsiveness has been shown to predict language outcomes (Tamis-LeMonda et al., 2001). Infant joint attention behaviours measured experimentally have also been shown to predict language outcomes (Brooks & Meltzoff, 2005, 2008). We wished to assess complementary joint attention behaviours of infants and their mothers in a single situation. Our aim was to assess both infants and their mothers in a genuine and sustained learning environment. To do so we implemented a methodology to assess both maternal and infant contributions in the same naturalistic interaction concurrently by using a single micro-level behavioural coding system. Mothers and their 14-month-old infants participated in 10-minute free play interactions in a university laboratory. We coded mother and infant attention independently, using a fine-grained coding system that has been used in a number of studies of maternal responsiveness and infant attention (Bornstein, Suwalsky, Ludemann, Painter & Schulthess (1991). We then combined those codes to compute the likelihood that a mother encouraged attention to an object, given that her infant was already attending to it (*maternal follow-in*) and the likelihood that an infant attended to an object given that the mother encouraged attention to it (*infant follow-in*). Both likelihood measures were odds ratios. Maternal follow-in identified situations in which the mother followed an infant's attentional state and as a result, joint attention was established. Infant follow-in identified situations in which the infant followed the mother's attentional state, and as a result, joint attention was established. We then examined the predictive power of each variable (maternal follow-in and infant follow-in) for language development at 14, 16, 17 and 18 months (measured as productive vocabulary size).

In this study three hypotheses were examined. First, in keeping with previous work, we hypothesized that maternal follow-in at 14 months would predict language development from 14 to 18 months. Second, we hypothesized that infant follow-in at 14 months would predict language development from 14 to 18 months. Finally we considered infant follow-in to be an important indicator of the infant's active contribution to establishing joint attention, and therefore hypothesized that infant follow-in would be a better predictor of language development than maternal follow-in.

Method

Participants

Mothers were recruited in their third trimester of pregnancy to take part in First Steps, a longitudinal study of development from birth to 18-months, which has since been extended to four-years, (see Ellis-Davies, Sakkalou, Fowler, Hilbrink & Gattis, 2012). This recruitment took place in community groups. Of the 39 mother/infant dyads initially recruited, 36 infants (19 boys, 17 girls) were included in the analyses reported here. Exclusion criteria were failure to complete the interaction (P36 & P38), and any referral for developmental delays (P18). Infants came from a range of socioeconomic and maternal education backgrounds. Although all infants' data was included in the analysis 4 infants missed vocabulary testing at one of the four time points. The majority (N=29) were first language English speakers. A further 7 infants were bi-lingual or second language speakers. Monthly testing sessions took place either on campus at Cardiff University or in a local community facility. Parents were given £25 in shopping vouchers at each of their monthly visits and a final £250 upon completion of the study. For more information on the sample and study see Ellis-Davies, Sakkalou, Fowler, Hilbrink & Gattis, (2012).

Procedure

Infant Vocabulary Growth Measure. Vocabulary acquisition scores were obtained using the Oxford University Babylab U.K adaptation of the MacArthur-Bates Communicative Development Inventory (OCDI: Hamilton, Plunkett & Schafer, 2000). Parents completed all sections of the OCDI when their children reached 14, 16, 17 and 18-months of age. Vocabulary production scores for the infants were the outcome variables of interest for the current study.

Interaction Coding. During the monthly testing session at 14-months mothers and their infants were left alone with a standard set of age appropriate toys. These "free play" interactions were filmed and the first 10-mins of uninterrupted interaction were used for coding the variables of interest.

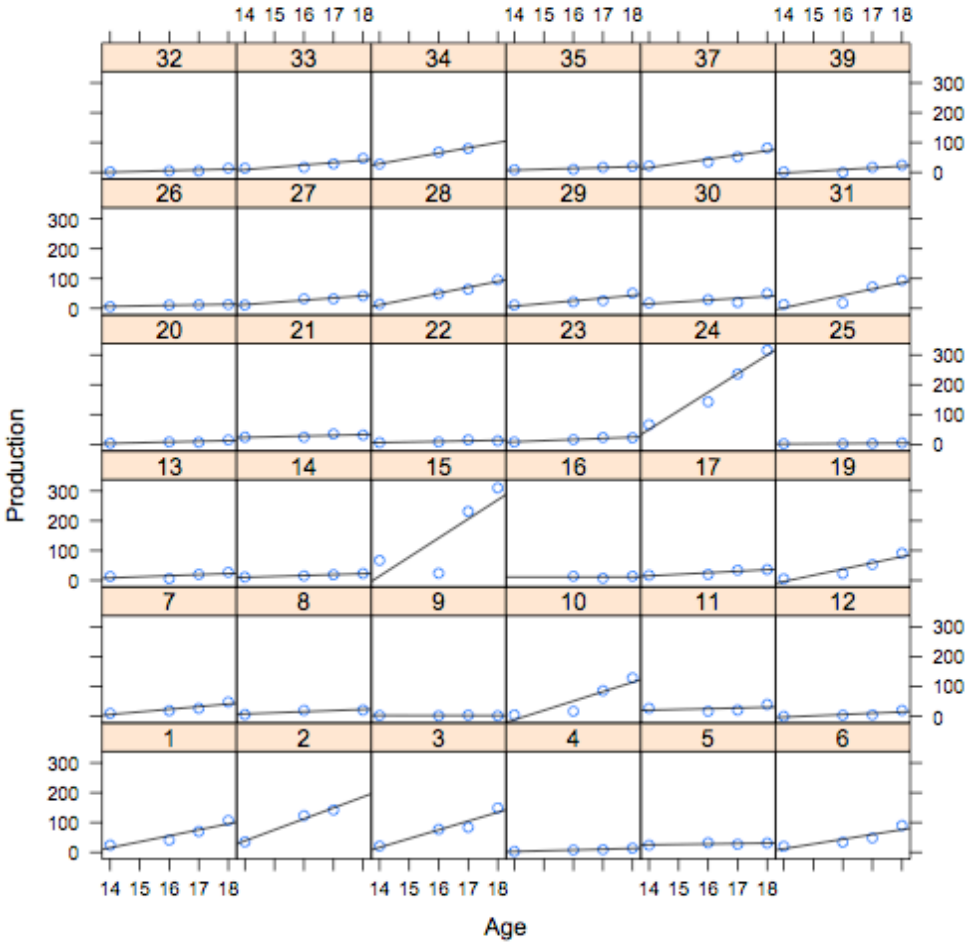


FIGURE 1. Scatterplots and regression lines of vocabulary production and age for all infants who met inclusion criteria.

Interactions were coded using mutually exclusive and exhaustive coding scheme as described in Bornstein, Suwalsky, Ludemann, Painter & Schulthess (1991). Using Mangold® (2010) INTERACT software infant attention and maternal encouragement of attention behaviours were coded if they met or exceeded one second in duration. Infant codes were limited to: look to object; look to caregiver; or none/not visible. Maternal codes were limited to: physical or verbal encouragement of attention to object; encouragement of attention to caregiver; or none of the above. Interrater reliability was based on 10% of interactions. Cohen's Kappa was .64 for infant attention and.8 for maternal encouragement. This study was particularly interested in the didactic behaviours of both parties. Once interactions were coded using the two modes a sequential analysis was carried out following the procedures of Bakeman and Quera (1995) and Bakeman and Gnisci (2005). This computed odds ratios, descriptive measures of effect size, for our variables. Odds ratios were computed using episodes where the target follow-in behavior commenced within 3-secs of the preceding behavior beginning. If target behaviours were more likely to be initiated during points when the corresponding behaviour was ongoing (as opposed to any other times) these odds ratios were greater than 1. The Generalized Sequential Querier program (GSEQ version 4.1.2;

Bakeman & Quera, 1995) was used to compute these values. Infant follow-in was classified as: the infant looks to object given maternal encouragement of attention to object. Maternal follow-in then was classified as: maternal encouragement of attention to object given infant attending to object.

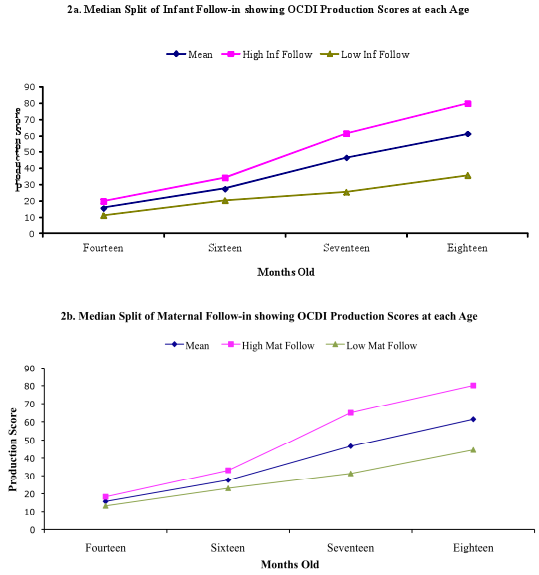
Results

Productive vocabulary scores

As reported in previous work (eg., Brooks & Meltzoff, 2008), productive growth increased rapidly across these age ranges in our sample (Figure.1). As expected mean productive vocabulary scores across children at each age correlated strongly and positively. The mean at each data collection point was significantly different from the others with the only exception being between 16-month (M=27.58, SD=31.07), and 17-month (M=46.63, SD=55.75), values.

Interaction coding results

The sequential analysis odds ratios (N=36), were generated giving a probability of the examined sequence over others. Infant follow-in (M=1.15, SD=.33), and maternal follow-in (M=1.22, SD=.52), correlated positively (r=.38, p=.02). There was no significant difference between these values t(35)=-.78, p=.44). Individual correlations between infant follow-in and vocabulary production at each time step were between r=.34 and r=.42, and were all significant, p<.05. Maternal follow-in correlations were non-signifcant, ranging between r=.07 and r=.23. In order to consider the data from all measurement points together in a single overall analysis, we turned to growth curve models (GCMs).



Figures.2a & 2.b. Line-graphs showing production scores (mean number of words) over time in months based on median split values of subjects on infant follow-in (2a) and maternal follow-in (2b) variables.

Models of productive vocabulary growth

GCMs provide a powerful tool for investigating the impact of predictor variables on both the overall performance and accelerated growth of productive vocabulary (Mirman, Dixon & Magnuson, 2008). We perfomed a median split on our predictor variables (see Figure. 2a & 2b), and using the R (version 2.15.2 [2012-10-26]) package lme4 (Bates, Maechler & Dai, 2012) both random and fixed effects were input into the model and their predictive strength assessed. The best fitting model was a mixed effects model including random effects of participant on the intercept of a linear growth curve, coupled fixed effects of infant follow-in (median split high-low) on the intercept and on the slope; and fixed effects of other individual differences on the slope. With such models Akaike's Information Criterion (AIC), Bayesian Information Criterion (BIC), and Chi^2 are the most commonly used indices of goodness of fit. For our best fitting model these were: AIC=1311.6, BIC=1335 Chi^2=104.89, p<.001) (See Table.1 Model I1). Whereas the addition of maternal follow-in provided a significant improvement in fit over the baseline model of random effects of participant on productive vocabulary growth (see Model M1, Table.1), the addition of maternal follow-in provided no improvement over and above the inclusion of infant follow in. Infant follow-in is thus a better predictor of both absolute vocabulary values and rate of growth, where maternal follow-in only effects rate of growth and to a lesser extent.

Follow-up analysis

In order to eliminate the possibility that our infant follow-in variable was simply a function of how often an infant looked to objects or how long they looked to objects in total or the average duration of looks to object, a simple independent samples t-test was carried out to ensure these characteristics of the low and high groups were not significantly different. No differences between high and low groups were found for: number of looks to an object, t=-.54, p=.59; total duration of looking at an object, t=.7, p=.67; and average duration of looking at an object, t=.48, p=.64.

General Discussion

In this paper joint attention episodes between mothers and infants were evaluated, in order to examine maternal and infant contributions to joint attention and their relations to language outcomes. The duration of joint attention episodes has previously been correlated with language development (Markus, Mundy, Morales, Delgado & Yale 2001). It is thought to do so by helping children identify relations between objects and words (Baldwin, 1991; 1993). In this study we sought to elucidate a more specific picture of the components involved. Previous work has demonstrated maternal contributions to joint attention influence vocabulary development (Carpenter et al., 1998; Tamis-LeMonda et

al., 2001). We used naturalistic interactions to evaluate infant and maternal contributions to joint attention in comparable ways. Results from our Growth Curve Analysis models showed that both infant and maternal follow-in behaviours contributed to rate of language growth. Furthermore infant follow-in made the most sizeable contribution to the model: infants' tendency to look at objects after being encouraged to so do was strongly related to productive vocabulary size and growth over the next 4 months. It is not simply infants who look more frequently to objects, or show sustained visual attention whose productive vocabularies are higher. The follow-in variable rests upon the infant's visual attention being temporally contingent on the encouragement of their parent. The current paper provides support for a model in which it is infant and not only maternal offerings to early word learning situations that are substantial (Smith & Yu, 2010; Yu & Smith, 2012). For productive vocabulary at 14 months-old it is important that infants respond appropriately to mothers' encouragement of attention by attending to objects, thereby establishing joint attention.

Table 1: Table of growth curve model estimated fixed effects and model fits.

	Model			
Fixed Effects	Baseline	I1	M1	IM1
Age	12.05	.34	.05	19.84
Age*Infant Follow-in		7.7		-11.02
Age*Maternal Follow-in			8.21	-11.85
Age*Maternal follow-in*Infant follow-in				11.21
Model Fit				
AIC	1435	1312	1329	1317
BIC	1446	1335	1352	1352
Chi^2		104.89**	19.35**	2.36*

Pr(>Chi^2) = p<.05*, p<.001**

Such results suggest that those infants who can effectively respond to and engage in shared experience are then able to efficiently attend to the subsequent maternal contributions held within it. That is during play between mother and infant, when a mother is encouraging their infants' attention to an object the infant then responds to this encouragement by sharing their mothers' attentional focus. In such situations, joint attention is achieved by the infant following into their mother's focus of attention. The positive predictive nature of maternal contributions within already established periods of joint attention, as opposed to outside them, has been previously documented (Tomasello & Farrar, 1986). Once infants establish a period of joint attention by orienting to a point of shared reference with their parent, given meaningful encouragement to do so, the subsequent information relayed can aid forming new associations (Waxman & Gelman, 2009).

These findings then add to evidence that global attributes of joint engagement and specific individual differences in the protagonists contributing to it are crucial in guiding language outcome. Our results confirm and extend prior reports that individual differences in infants' abilities to respond to joint attention attempts between 6 and 18-months relate positively to vocabulary development (Morales, Mundy, Delgado, Yale, Messinger, Neal & Schwartz, 2000). Future studies should investigate this relation further by comparing the contributions of maternal initiation and infant follow-in to joint attention.

By assessing maternal and infant contributions to joint attention in comparable ways within a single naturalistic interaction we have been able to advance beyond previous studies. Such temporally precise micro-analytic analysis of attention has been previously encouraged as a means to elucidate the processes of word learning (eg., Yu & Smith; 2010, Yu et al., 2011). We aimed to bridge a gap between the micro-analytic measurement-techniques used previously in experimental word learning settings, and a significantly more naturalistic situation. Previous experiments judged word-learning performance on those novel items included in the experimental task. We have moved beyond this to show that global productive vocabulary (as measured by the OCDI) benefits significantly from infants being able to detect and respond successfully to attempts at joint engagement during periods of unconstrained play. Infant follow-in, over and above maternal follow-in, is a novel and valuable predictor of vocabulary development. Future research should address what quality of the episode underlies this result.

Conclusions

As early as 14 months the selective visual attention of infants in response to maternal encouragement is predictive of both concurrent and future linguistic success. In this study we demonstrated, as reported previously, responsive caregivers impact infant vocabulary size positively. Moreover, for the first time in this study, the infant's response to joint attention was shown to account for a higher proportion of vocabulary growth.

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