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What paves the way to conventional language? The predictive value of babble, pointing, and socioeconomic status

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Abstract

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Keywords

paves, way, socioeconomic, conventional, status, language?, predictive, value, babble, pointing

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Abstract

A child's production of first words marks the emergence of a uniquely human ability to use linguistic conventions to direct others' attention. Theories of the developmental steps that pave the way for word production propose that either vocal or gestural precursors are key. We tested these accounts by assessing the developmental synchrony in the onset of babbling, pointing and word production for a group of 46 infants who were observed monthly between the ages of 9 and 18 months. Babbling and pointing did not develop in tight synchrony, and babble onset alone was a predictor of word production onset. Pointing and maternal education emerged as predictors of lexical knowledge only when a later measure taken at 18 months was considered.

What paves the way to conventional language? The predictive value of babble, pointing and SES.

The hallmark of human communication is the use of linguistic conventions: words and grammatical structures that function as inter-subjectively shared symbols. Although infants begin to show sensitivity to the association between common words and their referents around six months of age (Bergelson & Swingley, 2012), most children typically do not produce them until after their first birthday. Only at this latter point can we say that they can use conventional language to direct others' attention. There are very large individual differences in the age at which infants make this transition to word production. Proposals as to why infants begin producing words when they do tend to focus on infant readiness in terms of either gestural or vocal precursors, and reflect theoretical proposals about the evolutionary origins of language. Thus, while some would argue that the phylogenetic and ontogenetic origins of language are vocal (MacNeilage & Davis, 1993), others have recently argued that the gestural domain is more important (Tomasello, 2008). Very little has been done to pit such theories against each other and weigh up the relative contributions of vocalisation and gesture as predictors of word onset. Indeed, regardless of whether ontogeny recapitulates phylogeny, there have been calls in the developmental literature for a more integrated approach to the study of predictors of word learning (Hall & Waxman, 2004).

There are several problems with this state of affairs. First, it is possible that an infant's vocal and gestural abilities in fact reflect a single underlying construct of communicative readiness, such that they are reflections in different modalities of some more fundamental facility (Bates & Dick, 2002; McNeill, 2000). Indeed, pointing and babble do co-occur from early in development and are both lateralised in the left hemisphere (Cochet & Vauclair, 2010; Franco & Butterworth, 1996; Iverson & Fagan, 2004; Masataka, 1995;

Willems & Hagoort, 2007). By this account, the development of babble and pointing should be correlated, with children who are communicatively advanced developing both abilities earlier. In this case, neither modality would necessarily be a better predictor of early word learning.

Second, if the two modalities turn out to follow different developmental trajectories, then the question becomes whether theoretical accounts that place more importance on gestural or vocal origins hold when both precursors are weighed up simultaneously. Work on either side of the debate has tended only to measure the precursor of interest to that theoretical line of thinking, rather than considering its contribution alongside development in the other modality (e.g., Goldin-Meadow, 2007; Stoel-Gammon, 1998). As well as being of theoretical importance, considering both modalities together has practical consequences in terms of the early identification of risk factors for language development (e.g., Oller et al., 2010).

Third, it is possible that early vocal and gestural abilities are affected by the caregiver, whose mode of interaction may in fact be responsible for any observed relations between precursors and the onset of word production. Caregiver education has been shown to be positively correlated with the quantity of infant directed speech and the quality of parental responses to their infant's attention, gestures and vocalisations (Bornstein, Haynes, & Painter, 1998; Hoff, 2003a, 2003b; Hoff-Ginsberg, 1991; McGillion et al., 2013; Mundy et al., 2007). This latter difference in responsiveness is thought to be especially important when explaining variance in early lexical development since, at this stage, learning is more likely to occur if the caregiver talks about what the infant is already attending to (Hoff, 2003b; McGillion et al., 2013). It is, therefore, vital to control for this when assessing the relationship between infants' pre-linguistic skills and their word learning. However, despite much recent research

on the effect of caregiver education on language development, the focus has been on explaining what mediates or moderates this predictive relationship, with very little work weighing up this influence alongside the infant's own early communication skills (Demir & Küntay, 2014).

The goals of this study were to establish 1) whether early gestural and vocal behaviours emerge in synchrony; and 2) whether either modality is more important in predicting the onset of word production. In addressing the latter question, we controlled for the level of education of the primary caregiver as a proxy measure of language exposure. Our primary focus was on the age at which children produced their very first words (i.e., the transition to conventional language) and the number of words children were reported to produce at 18 months. To establish whether the predictors of word production were the same as for word comprehension, we also analysed parental reports of the number of words they thought their child understood at 18 months. We chose the vocal and gestural predictor that each literature suggests is most important for predicting word onset. In the vocal domain this was the stable production of consonants, and in the gestural domain this was the onset of index finger pointing.

Vocal precursors to word production: Babble

Phonological ability, both perceptual and expressive, is a key ingredient of later language success (Kuhl, 2004; Stoel-Gammon, 1998; Vihman, 2014). In order to be able to understand and produce words, the infant must be able to perceive and produce the component speech sounds of their native language. From a production perspective, although typically developing infants vocalise from birth, speech-like sounds begin to emerge gradually only late in the first year life, as a result of anatomical and neuro-motor maturation (Vihman, 2014). This appearance of reduplicated or canonical babble (repeated syllables

containing a consonant e.g., bababa; dadada) between 6 and 8 months is considered by many to be an especially important precursor of language, both onto- and phylogenetically (MacNeilage & Davis, 1993; Lieberman, 2002; Oller, 2000). Early babble of this form can be viewed as a milestone of motor development - a type of rhythmic vocalisation related to other forms of motor development across the first year of life (Campos et al., 2000; Iverson & Fagan, 2004; Kent, 1984; Thelen, 1981; Thelen, Ulrich, & Wolff, 1991). However, as it develops, it can also be considered a language milestone reflecting the infant's sensitivity to, and use of, the sounds of their native language (Jusczyk, 1997). In addition to the infant's physical maturation, it is increasingly accepted that the production of infant babble is at least somewhat contingent on exposure to the adult ambient language (Oller & Eilers, 1988). Phonological patterning, prosody, and consonant shape in babble have all been shown to be influenced by the infant's language environment (Oller et al., 2010). Moreover, the appearance of consonants in pre-linguistic vocalisations has been related not only to the production of words (McCune & Vihman, 2001) but also to their phonological shape. i.e., consonants used in early babble are often the consonants used in first words (Vihman, Macken, Miller, Simmons, & Miller, 1985). In the more recent studies, the measure used to capture the onset of babble is the age at which infants first demonstrate the stable use of two supraglottal consonants, and we adopt that measure here.

Gestural precursors to word production: Pointing

Pointing, specifically index finger pointing, is often considered the first true means of triadic referential communication available to the infant, setting it apart from other gestures, such as showing, which arguably has a more phatic function (Liszkowski & Tomasello, 2011). The prototypical pointing hand shape, index finger extended with the remaining digits curled inwards, emerges as early as 3 months of age. However, it is not until the infant extends both arm and finger, between 9 and 15 months, that this behaviour is associated with

a system of shared intentionality and communicative intent on the part of the infant (Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998; Tomasello, Carpenter, & Liszkowski, 2007). In contrast to the above accounts proposing vocalisation as the gatekeeper to language, it has been argued that this latter developmental step, producing declarative pointing gestures, provides the foundation on which linguistic communication rests, both developmentally and from an evolutionary perspective (Butterworth, 2003; Goldin-Meadow, 2007; Tomasello, 2008). This claim has been borne out in a growing number of studies where pointing, in particular index finger pointing, has been robustly associated with later vocabulary (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Colonnesi, Stams, Koster, & Noom, 2010; Desrochers, Morissette, & Ricard, 1995; Iverson & Goldin-Meadow, 2005; Özçaliskan & Goldin-Meadow, 2005). What underpins this relationship is, however, not well understood. Some argue that the onset of pointing reflects the emergence of new social-cognitive abilities and social motivations, which are required for subsequent word production (Tomasello, Carpenter & Liszkowski, 2007). Thus, Tomasello (2001) argued that, while children can make speech sounds and make associations well before the first birthday, it is only with the advent of new social cognitive skills emerging in the 9-12 month period that infants are capable of really appreciating what a word is: an 'intersubjectively understood linguistic symbol used to direct and share attention with other persons' (Tomasello, 2001, p. 1120). A second (non-mutually exclusive) possibility is that the infant's referential gestures prompt caregivers to respond by producing words in a context that is optimal for learning (Kishimoto, Shizawa, Yasuda, Hinobayashi, & Minami, 2007; Petitto & Marentette, 1991). That is, when infants point to things, parents can translate this gesture into conventional language at a moment when the infant is jointly attending to both the word and whatever it is denoting. On both accounts, early onset of pointing should predict early onset of word

production (so long as the child has a minimal phonetic repertoire with which to produce words).

The Current Study

This study sought to establish whether early gestural and vocal behaviours emerge in synchrony (and are thus potentially reflections in different modalities of the same communicative readiness construct) and, if not, whether either modality is more important in predicting the onset of word production and levels of expressive and receptive vocabulary at 18 months. To achieve this, we analysed a densely sampled set of video recordings of 46 infants interacting in naturalistic play sessions with their primary caregiver (in each case their mother), between the ages of 9 and 18 months. This data set allowed us to establish the month in which infants were reliably observed to produce consonants, to point, and to produce their first words.

Method

Participants

Participants were drawn from a larger sample of 59 parent-infant dyads, who had previously participated in a longitudinal study of early phonological development (DePaolis, Keren-Portnoy, & Vihman, in preparation). These families were recruited in the North of England via advertisements in the local press and infant-focused community groups. Eleven dyads were ineligible for inclusion in the current study (as caregivers did not give consent for their data to be used in other research); a further infant was excluded due to a developmental disorder and a final dyad was excluded because the primary caregiver did not participate in play recordings. Thus, the final sample for the present study included 46 parent-infant dyads. Twenty-one of the infants were boys, 21 were first born, and all came from monolingual

English-speaking families where the mother was the primary caregiver. All infants were full-term and had no known hearing or developmental disorders. Seventy per cent of mothers and 50% of fathers had a university degree.

Procedure & Transcription

Dyads were video-recorded in their homes engaging in 30 minutes of naturalistic play when the infant was between 9 and 18 months old. A research assistant remained in the room with the dyad for the duration of the recording, moving the video camera to ensure the infant remained in shot. Initially, recordings were made weekly, then bi-weekly (when the infant turned 13 months), dropping to once per month when the infant demonstrated consistent use of 2 supra-glottal consonants (or Vocal Motor Schemes; McCune & Vihman, 2001). A demographic questionnaire administered on the first home visit at 9 months measured, amongst other information, birth order and parental education. A parental report of expressive and receptive vocabulary, the Oxford Communicative Development Inventory (OCDI; Hamilton, Plunkett, & Schafer, 2000), a modified, UK version of the MacArthur Bates Communicative Development Inventory (Fenson *et al.,* 1994), was collected monthly. Participants were given £10 upon each home visit to thank them for taking part.

Infant vocalisations were phonetically transcribed by a team of three trained research assistants (including the first author) using EUDICO Linguistic Annotator software (ELAN; Sloetjes & Wittenburg, 2008).

Measures

Babble onset was characterised as the stable production of two supra-glottal consonants (stops, nasals, fricatives excluding /h/, or affricates). A consonant was considered to have reached stable production status if it fulfilled one of two criteria: (1) A minimum of

ten tokens of the given consonant were produced in each of at least three out of four consecutive half-hour sessions (McCune & Vihman, 2001); or (2) a total of 50 or more tokens of the given consonant were produced in one to three successive recording sessions (DePaolis, Vihman, & Keren-Portnoy, 2011). Stable consonant production was dated to the first home visit where the infant's production matched either of these criteria. The onsets of first and second consonants were positively correlated ($r = 0.756$; $p < 0.01$). Age at onset of the second stable consonant is preferred here as a measure of babble, primarily because age of acquisition of the first stable consonant correlated with infant age at first home visit ($r = 0.299$; $p = 0.044$), but also because this measure of second consonant production has previously been found to be correlated with referential word learning (McCune & Vihman, 2001).

Pointing onset was coded according to amended criteria from Matthews, Behne, Lieven, and Tomasello (2012). We coded index finger pointing uniquely as it has been identified both theoretically (Butterworth, 2003) and empirically (Colonnesi et al., 2010) as the most important pre-linguistic pointing behaviour. Recordings were viewed, in order, by a trained research assistant until the infant was observed to spontaneously make an index-finger point. That is, whilst looking at the object or event of interest, the infant produced a point with their left hand, right hand, or both hands, such that that their index finger was clearly and visibly separate from the other fingers, which were partially or entirely curled back. To check the reliability of this point measure, we compared it with parental reports of onset, where available. At each home visit, caregivers were asked to complete a diary commenting on any new communicative behaviour their child had begun to engage in. Although parents were not specifically asked to report pointing behaviour, 50% (n = 23) of them did so spontaneously, remarking that their infant had begun to point since the previous home visit. For this subset of parents, we calculated the correlation between parent-reported age of point

onset (median = 312 days) and our estimated age of pointing onset from video coding (median = 385 days). The two measures were significantly correlated (r = .452, p =.03). To further check the reliability of the video-coded measure of pointing onset, we asked a research assistant, blind to the hypotheses of the study to watch video recordings selected just before and just after we had originally estimated infants to have started pointing for the presence of pointing behaviour. To check that infants hadn't started pointing before our estimated onset date, we randomly selected 20% (n = 9) of the recordings from the month preceding the observed pointing onset. No infant was observed to point in these sessions. To check whether, once infants started to point, they would reliably do so in subsequent sessions, we coded pointing gestures in the sessions following that in which we had first observed each infant pointing (n = 45; one infant was first observed to point in their final session). 51% (n = 23) were observed to point in the session that immediately followed their first observed index finger point. A further 27% (n = 12) were next observed to point two sessions after they were first observed to do so with the remaining 22 % either pointing within 2 further sessions or reaching 18 months old (when recordings stopped).

Maternal and paternal education was coded on a 5-point scale based on a modified version of Hobbs and Vignoles' (2007) classification system: Level 1: No qualifications; 2: vocational qualifications; 3: GCSE or equivalent (UK exams typically taken at 16 years of age); 4: A levels or equivalent (UK exams typically taken at 18 years of age); 5: University Degree. Maternal and paternal education levels were positively related (r = 0.538, $p < 0.01$), thus only maternal education was included in analyses as the mother was the primary caregiver for all dyads.

The infant's age at the first session in which they spontaneously produced four different words was identified as the *4-word point* using Vihman and McCune's (1994) word

identification procedure. This method of classification considers both the phonetic shape of vocalisations and contextual criteria to identify target words. Word candidates are scored on 1) their phonological similarity to the intended adult target, 2) the availability of a plausible referent in the immediate context, and 3) the consistency with which the same form is used for the same referent.

The OCDI (Hamilton *et al.,* 2000) was used to measure the infant's *expressive and receptive vocabulary knowledge at 18 months*. Expressive and receptive OCDI vocabulary scores were positively related (Table 2) and correlated negatively (and in the case of expressive vocabulary, significantly) with the observed age at 4-word point (Table 2). That is, the sooner a child reached the 4-word point, the greater their reported expressive vocabulary at 18 months.

Reliabilities

The stable production of consonants in babble and of word forms was coded by three trained research assistants, including the first author. Four 3-minute video excerpts, randomly selected from recordings collected when the infant was 10 months of age, were used to calculate transcription reliability. These segments were phonetically transcribed by all three research assistants and reliabilities calculated in terms of the percentage agreement as to possible consonants (/p, b/, /t, d/, /k, g/, m, n, ŋ, l, s) between every two transcribers. Average agreement was 69% (range 65% - 72%), although this rose to 80% (range 76% to 89%) when the infrequently used consonants /l/ and /s/ were excluded. Only a small number of infants had /l/ (n=3) or /s/ (n=2) as one of their criterion consonants. This is in line with similar studies involving the transcription of pre-linguistic babble (DePaolis, Vihman, & Nakai, 2013; Majorano, Vihman, & DePaolis, 2014; McCune & Vihman, 2001). Since this study used these transcriptions to establish the point at which each infant could produce two

consonants and four words, the first author re-watched each infant's video recordings and double checked that they had met criterion on the date calculated and not before or after.

Pointing was coded by a trained research assistant. A sample of infants (11/46 or 24% of the entire group), randomly selected, was independently coded by the first author. Pearson's correlations indicated excellent agreement (r = .99, $p < 0.01$). Disagreements and borderline cases were discussed and resolved. Finally, the gesture produced at observed pointing onset for each infant was checked and confirmed by the first and final authors.

Results

We first explore the relationship between pre-linguistic babble and pointing before considering how each of these behaviours relates to maternal education. Next, we report regression models that test how these three measures relate to first word production and expressive and receptive vocabulary at 18 months.

What is the Relationship between Babbling, Pointing, Maternal Education and Infant Language?

There were large individual differences in age of onset of both babble and pointing. Babble onset tended to precede the onset of index finger pointing. The median age for the onset of babble was three months before that of pointing, at almost 10 months of age. All infants had begun to babble by 15 months and to point using their index finger by 18 months. Descriptive statistics for pre-linguistic infant measures and maternal education are presented in Table 1. The cumulative percentage of children beginning to babble and point, month by month, is presented in Figure 1.

[Please insert Table 1 & Figure 1 about here]

As can be seen in Table 2, infant pointing onset and babble onset were not significantly correlated, suggesting that they are not different measures of a single 'communicative readiness' construct. Consistent with previous findings in the literature, maternal education was not related to babble onset (Oller, Eilers, Basinger, Steffens, & Urbano, 1995). However, there were small to moderate correlations between maternal education and pointing onset and between maternal education and receptive and expressive language at 18 months.

[Please insert Table 2 about here]

What Best Predicts First Words?

Age at babble and pointing onset and maternal education were used to build regression models predicting the age at which infants were first observed to produce four words (4-word point). Model selection was performed by comparing all possible combinations of predictors including a null model (R Core Team, 2014). The best fitting model was one with babble onset alone as a predictor. This was a significant improvement on a null model (Table 3). The addition of pointing onset or education gave no improvement to any model, including the null model. It is worth noting that some children produced four words before they were observed to point (n = 6), suggesting that this gesture is not a necessary precursor of word production.

[Please insert Table 3 about here]

What Best Predicts Expressive and Receptive Vocabulary at 18 months?

Model comparison was again performed to identify the best account of expressive vocabulary and receptive vocabulary development at 18 months. For expressive vocabulary, the best fitting model included babble onset and maternal education as predictors (Table 4). The addition of babble onset to a model with maternal education alone also gave a significant improvement ($F(1, 44) = 8.103$, $p = 0.007$), as did the addition of maternal education to a model with babble onset alone ($F(1, 44) = 4.252$, $p = 0.045$), indicating that these predictors explain separate variance. The addition of pointing onset gave no clear significant improvement to any model. Considered alone it gave no improvement on a null model. When added to a model with babble onset and maternal education, it gave a marginal improvement ($F(3, 42) = 5.878$, $p = .002$).

[Please insert Table 4 about here]

For receptive vocabulary, the best fitting model included pointing onset and maternal education as predictors (Table 5). When considered alone, maternal education gave a significant improvement over the null model ($F(1,44) = 4.268$, $p = .045$), but pointing did not ($F(1,44) = 2.712$, $p = .107$). The addition of pointing onset to a model with maternal education alone gave a significant improvement ($F(1, 43) = 6.5932$, $p = .014$), as did the addition of maternal education to a model with pointing onset alone ($F(1, 43) = 8.245$, $p = .001$), indicating that these predictors explain separate variance. The addition of babble onset gave no clear significant improvement to any model. Considered alone it gave no improvement on a null model ($F(1,43) = 2.812$, $p = 0.1007$) . When added to a model with pointing onset and maternal education, it gave a marginal improvement ($F(3,42) = 5.405$, $p = 0.003$).

[Please insert Table 5 about here]

Discussion

This study found that early babbling (consonant production) develops independently of pointing and maternal education. When all three factors were considered, only babble emerged as a predictor of the onset of word production. When later measures of vocabulary were considered, babble and maternal education emerged as predictors of word production whereas pointing and maternal education predicted word comprehension.

These findings suggest that phonological readiness is more important for the transition to word production than previously recognised. Since infants are typically found to be engaging in canonical babble from around 6-8 months (Oller, 1980), and even learn some sound-referent associations at this age (Bergelson & Swingley, 2012), it would be easy to think that they have, so to speak, jumped the articulatory and associative hurdles and that only social cognitive developments would be left to determine when infants began to produce words. Yet, this does not appear to be the case. Practice with babbling continues to be a strong constraint on the onset of word production and one that appears to be unaffected by maternal education. This finding has potential clinical value, especially since recent developments in the recording and analysis of infant vocalisations make it easier to assess whether an infant is vocalising in a typical way (Oller et al., 2010).

Why might babble onset predict later productive vocabulary? Given the gap between the onset of the vocal motor schemes and the first words studied here, it seems unlikely that the explanation is simply that one needs to be able to produce speech sounds in order to produce words. More likely is that the very act of vocalizing tends to elicit language from caregivers that will, first, encourage more vocalisations and, second, assist infants in identifying the function of first words (Goldstein & Schwade, 2008; Vihman, 2014). It could also be that early babble onset reflects some third variable, not studied here, that is beneficial

for language learning. Further individual differences studies including theoretically important factors such as imitative learning capacity would be valuable in unpicking this, as would experimental studies that promoted the development of babble and tested for causal effects on later language.

The ability to point did *not* emerge as an important determinant of the onset of word production. Of course, unlike the production of speech sounds, it is not a necessary component of word production. However, the act of pointing is thought to represent the first means of going beyond dyadic interaction and intentionally directing others' attention to the external world. Whereas first instances of babbling appear devoid of communicative intent (and are considered a motor milestone not a social one), first acts of pointing can readily be interpreted as imperative or declaratives acts. For this reason, it is the act of pointing that has been argued to pave the way for language production (Butterworth, 2003; Tomasello, 2008). Children in this study did tend to produce pointing gestures before their first words (only 6/46 children did not do so). But, other than this observation, we found no synchrony between the onset of index finger pointing and the onset of production of first words. It is not until we examine word comprehension at 18 months that there is a link between pointing and vocabulary development. This is in line with findings of a recent meta-analysis, which showed that the association between pointing and language development increases with age (Colonnesi et al., 2010). This suggests that, while the mastery of pointing may not be essential for getting word production off the ground, its use facilitates subsequent lexical development.

One might query whether the findings would have differed if we had considered a broader set of communicative gestures, for example, open handed points and/or 'show' gestures or indeed if we had used experimental paradigms to elicit pointing behaviour

(Liszkowski & Tomasello, 2011) rather than observe it naturalistically. We measured index finger pointing specifically as this has been argued theoretically, and found empirically, to be the most important predictor (Butterworth, 2003; Colonnesi et al., 2010). Whether or not using an experimental paradigm would have elicited more pointing behaviour from children at an earlier age is an interesting question. Some have observed that infants point more often in naturalistic settings in the home than in the lab (Leroy, Mathiot, & Morgenstern, 2009), but it's possible that taking a 'distal display' to the home and asking parents to carrying infants round on the hip to look at it might elicit more gestures. We also focussed on pointing onset rather than frequency since we were concerned with infants' capacity to engage in pointing (and babbling) rather than the frequency with which they did so. It is possible that the onset of pointing is constrained by factors internal to the child, whereas the frequency with which they go on to use the gesture depends heavily on socialization (Matthews et al., 2012). Future research might explore how frequency measures taken at different time points and compare to onset measures in terms of their predictive value.

While pointing was not a predictor of the transition to word use, it is possible that other measures of social cognition would be. In future studies, it would be prudent to explore, for example, the predictive value of gaze following, which has previously been found to predict later vocabulary development (Brooks & Meltzoff, 2005; Perra & Gattis, 2012). Likewise, while we measured very early word production in this naturalistic study, there was no equivalent measure of the onset of word comprehension. Obtaining a measure of early word comprehension is challenging since many dispute that the earliest tests of word-referent association are tests of word comprehension proper (e.g., Bannard & Tomasello, 2012). Nonetheless, maternal reports of comprehension at 18 months suggest that the onset of the pointing gesture and maternal education are more important predictors of receptive vocabulary. This is likely because parents tend to respond to infant gestures with relevant

words (Goldin-Meadow, Goodrich, Sauer, & Iverson, 2007). If this is the case, a key question remains to be answered: why does early babbling apparently not have the same language-eliciting effect?

It might be argued that parents are not likely to respond to babbling across the board, but only to what might be referred to as 'communicatively intentional babbling', where the infant's vocalisation is clearly intended to direct another's attention (Esteve-Gibert & Prieto, 2012; Goldstein, Schwade, Briesch, & Syal, 2010). Devising a list of clear markers of intention is a well-recognised challenge (Bruner, 1973). Consequently, we opted to have both pointing and babble onset coded without reference to extra indicators such as gaze alternation (as is standard, e.g., Colonnesi et al., 2010; Vihman, 2014) and without considering instances when these behaviours co-occur *(*Wu & Gros-Louis, 2014). In future studies it should prove fruitful to compare parental responses to infant gestural and vocal communication of different types, including their co-occurrence, to establish whether parents predictably respond to certain constellations of behaviour (Olson & Masur, 2013).

We conclude that the transition to conventional language is much more heavily determined by infants' prior vocal abilities than has previously been recognised.

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Tables and Figures

Table 1: Descriptive Statistics for Pre-linguistic Infant Measures and Maternal Education (N= 46)

	Minimum	*Maximum*	*Median*	*SD*
Babble onset (age in days)	277	464	298	47.254
Pointing onset (age in days)	283	559	385	76.017
Maternal education	2	5	5	.809

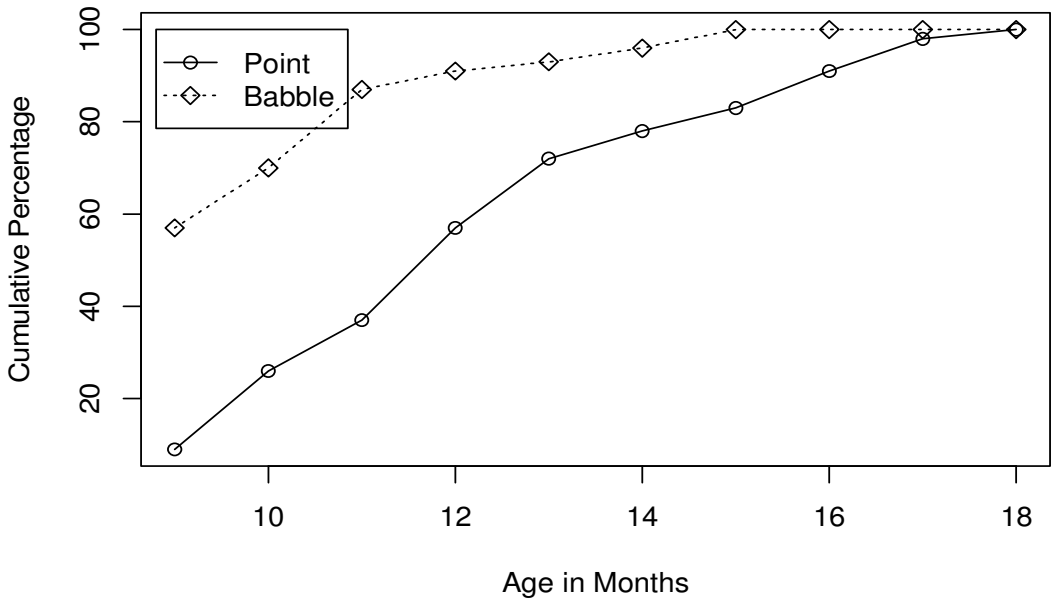

Figure 1: Cumulative Percentage of Infant Babble and Pointing Onset as a function of age in months (N=46)

Table 2: Correlation Coefficients (Pearson's r) among Pre-linguistic Infant Measures and Maternal Education (N=46)

	[1]	[2]	[3]	[4]	[5]	[6]
[1] Babble onset						
[2] Pointing onset	-.130					
[3] Maternal Education	-.079	.305*				
[4] 4-word-point	.470**	.091	-.038			
[5] Expressive vocabulary at 18m	-.402**	-.096	.306*	-.502**		
[6] Receptive Vocabulary at 18m	-.245	-.241	.297*	-.205	.521**	

** p<0.05; ** p<0.01.*

Table 3: Regression Model fitting Babble Onset to Infant Age at 4-word point

	B	*T*	*P*
Babble onset	.607	3.530	.001

R^2 = .221, F(1,44)=12.464, p =.001

Table 4: Regression Model fitting Babble Onset and Maternal Education to Expressive Vocabulary at 18 months

	B	*T*	*P*
Babble onset	-.411	-2.847	.007
Maternal Education	17.363	2.062	.045

R^2 = .237, F(2,43)=6.685, p =.003

Table 5: Regression Model fitting Pointing Onset and Maternal Education to Receptive Vocabulary at 18 months.

	B	*T*	*P*
Pointing onset	-.341	-2.568	.013
Maternal Education	35.855	2.871	.006

R^2 = .210, F(2,43)=5.702, p=006