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**Citation for published version:**

Cameron-Faulkner, T, Malik, N, Steele, C, Coretta, S, Serratrice, L & lieven, E 2021, 'A cross cultural analysis of early prelinguistic gesture development and its relationship to language development', *Child Development*, vol. 92, no. 1, pp. 273-290. <https://doi.org/10.1111/cdev.13406>

**Digital Object Identifier (DOI):**

[10.1111/cdev.13406](https://doi.org/10.1111/cdev.13406)

**Link:**

[Link to publication record in Edinburgh Research Explorer](#)

**Document Version:**

Publisher's PDF, also known as Version of record

**Published In:**

Child Development

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# A Cross-Cultural Analysis of Early Prelinguistic Gesture Development and Its Relationship to Language Development

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Many Western industrialized nations have high levels of ethnic diversity but to date there are very few studies which investigate prelinguistic and early language development in infants from ethnic minority backgrounds. This study tracked the development of infant communicative gestures from 10 to 12 months ( $n = 59$ ) in three culturally distinct groups in the United Kingdom and measured their relationship, along with maternal utterance frequency and responsiveness, to vocabulary development at 12 and 18 months. No significant differences were found in infant gesture development and maternal responsiveness across the groups, but relationships were identified between gesture, maternal responsiveness, and vocabulary development.

One of the most important milestones in infancy is the ability to share attention with others. Specifically, an infant's ability to draw a person's attention to objects or events heralds a new way of interacting with and learning about their world (Kita, 2003; Liszkowski & Tomasello, 2011; Rowe & Goldin-Meadow, 2009) though exactly when and how this ability emerges is still open to debate. Studies have documented qualitative differences across cultures in the ways in which infants are brought into the social world (see Brown & Gaskins, 2014; Gaskins, 2006 for excellent reviews) but to date research has focused either on the emergence of prelinguistic gestures, typically pointing, (e.g., Callaghan et al., 2011; Liszkowski, Brown, Callaghan, Takada, & de Vos, 2012) or the relationship between aspects of prelinguistic development such as gesture and maternal speech and early child language development (e.g., Tamis-LeMonda, Baumwell, & Cristofaro, 2012). In this study, we examine both phases of development through the longitudinal study of

infants and caregivers from three distinct cultural groups. We focused specifically on the development of deictic gestures (i.e., gestures used to identify a referent) as these are commonly viewed to have the greatest significance for conventional communicative development (e.g., Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998; Colonnaesi, Stams, Koster, & Noom, 2010; Iverson & Goldin-Meadow, 2005; Özçalışkan, Adamson, & Dimitrova, 2016).

Prelinguistic development of communicative abilities involves subtle, but systematic developmental transitions as infants move from primary to secondary intersubjectivity (Bakeman & Adamson, 1984; Bornstein & Tamis-LeMonda, 1990; Trevarthen & Hubley, 1978). Around the age of 10 months infants begin to produce proximal triadic gestures such as holding out and giving objects and reaching gestures (e.g., Bates, Camaioni, & Volterra, 1975; Fenson et al., 1994; Masur, 1983; Tomasello, 1999). Holding out and giving gestures (HoGs) increase in frequency over time though the

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The support of the Economic and Social Research Council (ES/L008955/1) is gratefully acknowledged. The authors also thank the families who kindly participated in this study. Thanks also go to Saki Chowdhury, Hamida Begum, Naomi Rose, Ziyun Zhang and Sage Juliusburger for all their help. This article is in memory of Dr Sylvia Sham.

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0009-3920/2021/9201-0017

DOI: 10.1111/cdev.13406

frequency of reaches tends to remain stable (e.g., Cameron-Faulkner, Theakston, Lieven, & Tomasello, 2015; Tamis-LeMonda, Song, et al., 2012). Following the emergence of HoGs and reaches, comes the most commonly studied deictic gesture, the index finger point which typically denotes a declarative, sharing motive. Index finger pointing emerges around 10–12 months of age and demonstrates a close relationship with the frequency of HoGs gestures (e.g., Cameron-Faulkner et al., 2015). Index finger pointing has attracted a great deal of attention due to its apparently species-specific nature and also because its frequency of use is a strong predictor of language development outcomes (see Colonna et al., 2010; Lüke, Grimminger, Rohlfing, Liszkowski, & Ritterfeld, 2017).

The relationship between proximal gestures such as HoGs, index finger pointing and early language development is indicative of a dynamic, social process involving gradual transitions in the way in which infants engage with their physical environment and the people within it (e.g., Bates et al., 1975; Carpendale & Lewis, 2004; Carpenter et al., 1998; Colonna et al., 2010; Özçalışkan & Goldin-Meadow, 2005; Reddy, 2010; Rohlfing, Grimminger, & Lüke, 2017; Rowe & Goldin-Meadow, 2009). There is some debate regarding the extent to which inbuilt cognitive processes underlie the emergence of triadic communicative abilities (e.g., Tomasello, 2008) though most, if not all, accounts of prelinguistic development highlight the role played by social interaction within the process. Social constructivist and process-relational accounts of development claim that both communicative gestures and language itself emerge through joint engagement and interaction (e.g., Carpendale & Lewis, 2004; Vygotsky, 1978; Werner & Kaplan, 1963). Researchers have suggested that infants learn that their behaviors have meaning through watching and anticipating the responses of their caregivers (Carpendale & Carpendale, 2010; Werner & Kaplan, 1963) and through everyday routine social interactions infants gradually develop a conventional, systematic repertoire of gestures which lead to a natural progression into language. In this approach communication is co-constructed afresh for each and every infant through interaction as infants are socialized into the communicative norms of their social group (e.g., Brown & Gaskins, 2014; Gaskins, 2006; Schieffelin & Ochs, 1986). Differences in the types of communicative strategies used between caregiver and child may well result in differences in patterns of communicative development. For this reason, it is important to look at key factors which may

contribute to different forms of interaction, for example, culture.

Studies regarding the relationship between culture and parent–infant interaction indicate a diverse range of practices and reflect the wide range of ecological niches within which children are raised around the world. Cultural differences in parenting and socialization are well-documented in the literature though they generally capture broad, high level distinctions. For example, cultural differences in child-caregiver interaction have been categorized according to whether they promote independence (i.e., encouraging children to learn and act as individuals) or interdependence (i.e., promoting commitment to group goals and close family networks; Keller, 2007; Lamm & Keller, 2007). This high-level distinction cascades down into everyday parenting and communicative behaviors leading to variation in the amount of time spent in distal parenting activities such as object play and face-to-face interaction (typical of independent parenting styles) or more proximal parenting activities involving close body contact, characteristic of interdependent parenting styles (Keller, 2007). Also, there are cultural differences in the extent to which parents treat their young as worthy conversational partners as demonstrated in the classical anthropological studies conducted by Schieffelin & Ochs (e.g., Schieffelin & Ochs, 1986; see also Brown, 2000; Farran, Lee, Yoo, & Oller, 2016; Lieven, 1994).

Cross-cultural studies of infant prelinguistic development demonstrate a complex picture of the interaction between culture and parent–child interactions (e.g., Bornstein, Putnick, Cote, Haynes, & Suwalsky, 2015). Two key themes have emerged over the years, one focusing on the emergence of prelinguistic gestures across cultures and the other concerning the patterns of social interaction associated with these early communicative infant gestures. In general, research indicates that infants display similar patterns of gesture development across cultures both in terms of age of onset and frequency of use. For example, Liszkowski and et al., (2012) studied the production of index finger pointing within a semi-experimental setting in infants aged 10–14 months from seven very distinct cultural contexts and found no evidence of cultural differences (see also Callaghan et al., 2011). Similarly, Tamis-LeMonda, Song, et al., 2012, did not find any significant differences in the number of gestures produced by infants from Dominican, Mexican, or African American backgrounds at 14 months, and Lieven and Stoll (2013) found that the infants in their Chintang and German

communities began to point at around the same age of 10 months. Interestingly though, significant cross-cultural differences were reported by Salomo and Liszkowski, (2013) who analyzed natural observations of Yucatec Mayan, Dutch, and Shanghai Chinese infants aged 8–15 months. The authors identified differences in terms of both the frequency of gesture use and the joint gesture events within which they were embedded. Therefore, the extent to which culture affects the emergence and use of prelinguistic gesture remains open.

Within parent–infant interaction the responsiveness of the caregiver to the infants' communicative bids appears to be a strong predictor of early language development. Studies investigating general aspects of responsiveness, that is, responsiveness to early communicative vocalizations and emotive behaviors prior to the onset of communicative bids, indicate cross-cultural differences. For example, Bornstein, Cote, Haynes, Suwalsky, and Bakeman (2012) investigated moment to moment contingencies in Japanese, Japanese American immigrant, and European American dyads (infants age 5.5 months) and found differences between cultural groups in terms of maternal responsiveness within mother–infant object-oriented interactions. Broesch, Rochat, Olah, Broesch, and Henrich (2016) analyzed maternal responsiveness in mother–infant dyads (infant age 7 months) from Fiji, Kenya, and the United States. The authors did not detect cultural differences in maternal responsiveness to infant bids for attention though they did find differences in terms of responsiveness to affective displays. Studies such as these indicate that patterns of responsiveness are apparent well before the onset of prelinguistic communication and display cultural differences.

When considering the relationship between maternal responsiveness and communicative development specifically, researchers typically focus on contingent talk, that is, the temporally and semantically connected speech that follows on from the infants' gestures or communicative vocalizations. Studies indicate that this form of responsiveness is positively associated with early vocabulary development (e.g., Hoff, 2003; Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991; McGillion, Pine, Herbert, & Matthews, 2017; Tamis-LeMonda, Song, et al., 2012; see Tamis-LeMonda, Kuchirko, & Tafuro, 2013; Tomasello & Farrar, 1986). There is a sound body of work demonstrating the wide variation among caregivers in terms of contingent talk, with a focus on the effects of socioeconomic status (SES; e.g., McGillion et al., 2017) but less is known

about the frequency of contingent talk across different cultural groups (Tamis-LeMonda, Song, et al., 2012). This is surprising given the wealth of studies demonstrating strong cultural differences in the extent to which caregivers are willing to treat their infants as communicative partners (Farran et al., 2016; Keller, 2007; Lieven, 1994; Schieffelin & Ochs, 1986) and also the ongoing debate regarding cultural differences in overall sensitive responsiveness to infants (e.g., Broesch et al., 2016; Mesman et al., 2018). Furthermore, there is some evidence to suggest that the normative patterns associated with robust communicative development in European cultures may not work the same way in nonindustrialized cultures (e.g., Mastin & Vogt, 2016) and so investigating contingent talk across cultures is an important avenue of research.

In this study, we investigated the relationship between culture, prelinguistic development and early vocabulary development. We situate the study within a dynamic sociocultural account of development in which infants learn the social significance of deictic gestures through interaction with experienced others, typically the infant's primary caregiver (Carpendale & Lewis, 2004; Salomo & Liszkowski, 2013; Vygotsky, 1978). We focus specifically on *infant-initiated* deictic gestures since we predict that infants who encounter success at drawing the attention of their caregiver to an object and eliciting a meaningful response will display accelerated communicative growth (e.g., Ger, Altunok, Liszkowski, & Küntay, 2018). We focused on three distinct and diverse (macro) cultural groups living within the United Kingdom of Great Britain (UK) namely Bengali, Chinese, and British. The British sample, constituted our "reference sample" (Salomo & Liszkowski, 2013) in that they reflected the general cultural sample found in most prelinguistic studies. When selecting our ethnic minority groups we were mindful of the dangers of making generalizations based on the limited number of studies involving prelinguistic development of non-WEIRD communities and the vanishingly small number of studies investigating prelinguistic development within these communities when living in host societies. Therefore, our main motivation for selecting our two ethnic minority communities was a consequence of practical as well as theoretical considerations. We selected mothers and infants from Bengali and Chinese speaking households as both communities are well represented in our study location and also some level of vocabulary measurement tools were available in the target languages of Bengali, Cantonese, and Mandarin.

At the time of writing we were not able to find any studies which systematically investigated patterns of parent-child interaction in our target groups when living in host European cultures but report here some potentially related findings. Broadly speaking, the research appears to indicate that families of South Asian heritage (though notably the research focuses on Indian families) may be more likely to foster interdependence and retain traditional family structures, for example, primary caregiving being the domain of female members of the family and elders maintaining the highest level of respect within the family unit (e.g., Assanand, Dias, Richardson, & Waxler-Morrison, 2005). In a study conducted on Euro-Canadian and Indian families the South Asian parents were more likely to adopt an adult-led model of infant play and exploration when compared with Western society families and were less likely to follow in to their children's focus (Simmons & Johnston, 2007). Similarly, Chaudhary (1999) found that South Asian parents rarely produced expansions in response to their children's early multiword speech. According to the literature, parenting in Chinese families may be viewed as a form of training leading to a more formal style of interaction than the child-centered play based nature of Western parents (e.g., Zhang, Jin, Shen, Zhang, & Hoff, 2008). At the same time Chinese family structure places the child as the center of attention (Goh & Kuczynski, 2009) and there is evidence to suggest that Chinese infants spend more time in joint triadic engagement than European infants (see Salomo & Liszkowski, 2013) though the extent to which caregivers engage specifically in infant-led interactions is an interesting question. Interestingly there is evidence to suggest that urban Chinese parents gesture more to their children than parents from the United States (Goldin-Meadow & Saltzman, 2000). The studies presented here are indicative of potential differences within the participants in our study. However, we retain an exploratory approach to this study and present our findings as a first step in exploring prelinguistic development and interaction in nonmajority cultures within the United Kingdom.

All three groups were matched for SES in order to increase the likelihood of any differences between groups being a consequence of culture as opposed to income and we chose to focus on minority language speaking families from lower SES households, measured in terms of educational level and the job of the main income earner. Our decision for focusing on lower SES households was

twofold. First, low-income ethnic minority families have multiple barriers to accessing English Language classes and consequently are less likely to have been strongly acculturated to the host culture and more likely to exhibit cultural differences in parent-infant interaction should they exist (Prevo & Tamis-LeMonda, 2017). Second, lower SES families have less representation in the developmental literature than middle class families but make up a larger proportion of the population and are over-represented in ethnic minorities. If we are to take generalizability seriously then we need to make every effort to include the majority groups in our studies.

This study had two aims; (a) to investigate the development of infant-initiated gestures and maternal responsiveness in our three cultural groups, and (b) to investigate the relationship between infant-initiated gesture use, maternal responsiveness, and early vocabulary development across the groups. We chose to follow a semistructured research design which involved all dyads taking part in the same activities with the same stimuli in community (e.g., family and children centers) as opposed to home settings. In a similar vein to Callaghan et al., (2011) our choice was motivated by our aim to ascertain the extent to which infants in the three cultural groups were able to produce our target gestures and whether they developed in the same way. In order to be sure that all infants had similar opportunities to produce these behaviors it was necessary to control the affordances of the environment. This decision comes at the cost of familial and cultural authenticity; that is, we may be able to show that infants can produce certain gestures and that when they do that their mothers will respond in certain ways, but this data cannot speak to the issue of whether the infants and mothers do actually use these interactional patterns in daily life. Our study has an exploratory status and as such we do not present hypotheses. Instead we state here some general expectations based on the existing literature. We expected to see similarities in gesture use between the ages of 10–12 months in infants across our three cultural groups but differences in the frequency of maternal speech and contingent talk between the cultural groups. Specifically, we expected to see more contingent talk in our English sample than our Bengali or Chinese sample. Finally, if cultural differences in the maternal measures are attested then we expected to find these differences reflected in the vocabulary development of the infants as measured by the Communicative Development Inventory (CDIs).

## Method

### *Participants*

Participants were drawn from a northern urban setting in the UK. Recruitment was conducted through community and family centers and targeted three distinct cultural communities; Bengali, Chinese, and English. Recruitment began in October 2014 and data collection ended in June 2016. Sixty infant–mother pairs were recruited with 20 from each cultural group. There were an equal number of full term boys and girls in each group and the age of all infants at the beginning of the study was 10 months. One of the pairs from the English sample did not complete the study due to infant mortality. All potential participants were asked a series of screening questions to ensure that the mothers were primary caregivers and “stay at home mothers” with no formal education past high school level, and lived in lower income households (see Table 1). The category of lower income was identified through the main occupation of the primary income earner to avoid any cultural sensitivity associated with questions pertaining to income levels. For the Bengali and Chinese mothers we also ensured that the language of the home was the native language of their community group. We did not directly measure levels of acculturation due to concerns that questions of this nature may be viewed as intrusive and a barrier to participation for some of the mothers. Instead the mothers were asked a small set of language-related questions and also asked about their participation in mainstream (i.e., English speaking) parenting groups, namely “stay and play” mother and baby groups. The mothers self-reported very low levels of English proficiency and very low levels of participation in English speaking mother and baby groups.

All caregivers were given a certificate of completion at the end of the study along with a copy of their 12-month data collection session.

### *Materials and Procedure*

The mother–infant pairs took part in two activities when the infants were aged 10, 11 and 12 months. The sessions were held in local community centers to ensure that the mothers and infants did not have to travel too far to attend the sessions. The rooms used were pleasant, minimally decorated, and typical of those used for parenting and family support activities. The first activity, based on Liszkowski and Tomasello, (2011) aimed to elicit pointing gestures from the infants. One side of the room was

decorated at parent head height with 16 objects of interest to infants (e.g., fairy lights, a mirror, and a balloon). The same set of objects was used in each community center and in each of the three sessions (i.e., at 10, 11, and 12 months). The mothers were instructed to walk by the decorated wall for 5 min, and see what their infants were interested in.

Next the dyads took part in two 10-min free play sessions on the floor with the aim of eliciting HoG gestures from the infants (Cameron-Faulkner et al., 2015). The mothers were asked to sit opposite their infants on a large play mat. The infants were supported by a V-shaped pillow when necessary. Two sets of 10 toys were used. All the toys could be explored by the infant with minimal/no input or manipulation from the mother (e.g., rattles, stacking cups, toy phone, toy fishing net, a rattle ball). The toy set was switched after 10 min to avoid boredom.

The research assistants recorded the sessions with handheld video cameras from the corner of the room. Handheld cameras were used instead of static recording equipment since some of the infants were mobile and freestanding cameras with tripods could be an unwanted target of interest during the free play sessions. In addition, by holding the cameras the research assistants were able to capture all aspects of the sessions even if the infants moved away from the mat in the free play session. The research assistants were already known to the mothers through the recruitment process and initial screening which helped to reduce the potentially intrusive nature of data collection. Data collection resulted in 72 hr and 23 min of recordings with comparable recording lengths for each group (Bengali mean duration of recordings per dyad 73 min 51 s (range = 69 min 27 s–75 min) Chinese mean length of recordings per dyad = 74 min 4 s (range = 69 min 1 s–75 min); English mean length of recordings per dyad = 74 min 2 s (range = 66 min 54 s–75 min).

### *Maternal Self-Report Questionnaires*

In order to measure the vocabulary development of our infant participants we used three versions of the MacArthur Communicative Development Inventory Words and Gestures which is designed for use with infants aged 8–18 months (Fenson et al., 1994). The CDIs were administered in face-to-face interviews between the mother and the research assistant in order to ensure that issues relating to literacy levels did not affect the completion of the questionnaire. The CDI was administered when the infants were 12 months and then

Table 1  
General Demographics of the Participants

		$M_{\text{age}}$	Number of participants born overseas	Mean year of arrival in UK	Mean age of education completion	Highest level of Education obtained		
						Primary School	High School	University
Bengali	Mothers	31 (range 23–42)	20/20	2007 (range 1998–2014)	16.4 years ( $n = 18$ ) (range 10–20)	2	18	0
	Fathers	39 (range 26–50)	14/20	2003 (range 1990–2014)	17.4 years ( $n = 9$ ) (range 12–21)	0	18	2
Chinese	Mothers	33 (range 23–46)	20/20	2009 (2002–2013)	16.7 years (range 13–19)	0	20/20	0
	Fathers	39 (range 30–52)	18/18	2003 (range 1989–2009)	16.7 years ( $n = 17$ ) (range 13–19)	0/18	18/18	0/18
English	Mothers	30 (range 22–45)	n/a	—	17.9 years (range 16–31)	0/19	19/19	0/19
	Fathers	35 (range 21–50)	n/a	—	17.9 years ( $n = 13$ ) (range 16–23)	0/16	15/16	1/16

Note. One Bengali mother and father were not sure of their age. One Chinese mother did not wish to give any information about the father of her child and another Chinese mother did not wish to give information other than her age. Not all participants were able to provide exact information on the age at which they or their partners completed formal education and so the number of participants if less than the sample total is shown in parentheses.

again when the infants were aged 18 months. Both the comprehension (“words understood”) and production (“words understood and said”) scores were used in this study. At the time of testing there were no normed versions of the CDIs in Bengali, British English, Cantonese, or Mandarin for use with U.K. populations. We used the Lincoln Babylab version of the CDI (a U.K.-adapted CDI) for our English-speaking infants (Meints, 2000). For the Chinese sample we used either the Cantonese CDI or the Mandarin (Beijing) CDI (Tardif & Fletcher, 2008) dependent on the mothers’ native language, and for the Bengali sample we used a modified version of Bengali CDI (McGregor & Hamadani, 2010). In the case of the Bengali and Chinese CDIs we replaced nouns which were not appropriate to a U.K. context and also added translated forms of words from the Lincoln Babylab CDI where appropriate. The final adaptations of the CDIs contained the same 19 major categories as the standard MacArthur CDI and contained comparable numbers of items (English, 397 items; Bengali, 388 items; Cantonese, 379 items; Mandarin, 403 items). The Chinese and Bengali CDIs were piloted on a sample of Chinese and Bengali mothers to ensure that all words were appropriate for the cultural context within which the infants were being raised.

#### Transcription and Coding

All video recordings were coded and transcribed by trained native/near native speakers of the target

languages using ELAN (Sloetjes & Wittenburg, 2008). The infant data were coded for the most commonly produced *infant-initiated* deictic gestures following Cameron-Faulkner et al., (2015).

1. *Reaches*: the infant’s arm is outstretched toward an object but the index finger is not extended.
2. *Hold outs*: the infant holds out an object with their arm extended toward the mother.
3. *Gives*: a single gesture in which the infant places an object in the proximity of the mother, usually by placing the object in the mother’s hands.
4. *Index finger points*: the infant stretches out their arm either partially or fully in the direction of an object and extends the index finger.

Hold out and give gestures were combined due to their relative low frequency in spontaneous infant-initiated communicative bouts (see Cameron-Faulkner et al., 2015).

All maternal speech was transcribed. A verbal utterance could contain more than one phrase or sentence so long as they were not separated by a pause of 2 s or more. Utterances containing only single word expressives or fillers (e.g., *oh*, *hey*, *uh-oh*) were not included in the analysis as the maternal utterances analysis focused only on linguistic items with semantic content. This decision was made because of the number of vocal signals which have to some extent communicative import (e.g., a heavy sigh) but are not necessarily linguistic. In

addition to the maternal speech transcription we also coded all instances of contingent talk. Contingent talk was defined as any utterance that (a) occurred within a 2-s window of an infant's communicative gesture (based on Bornstein et al., 2015; McGillion et al., 2013) and (b) made reference to the object/event of the infant's gesture.

We aimed for consistency in the duration of the activities (i.e., 5 min for the point elicitation and 10 min for each of the two play activities), but in cases where the recordings were too short (e.g., in cases where the infant began to fuss) we calculated a pro rata score. Our analyses are based on data from all three sessions combined (i.e., 5-min decorated room and the two 10-min play activities) in order to capture the maximum amount of data and gestures were counted regardless of task (e.g., points and reaches produced during toy play were also counted). For the analysis of the relationship between prelinguistic measures and vocabulary scores we pooled all the data from months 10–12 as the frequency of the behaviors was relatively low. Reliability coding was conducted on 10% of the infant gesture coding and contingent talk coding and signaled good levels of reliability on the infant gesture categories ( $K = .85$ ) and very good levels of reliability on contingent talk coding ( $K = .97$ ).

## Results

We fitted a series of generalized linear mixed-effects models (GLMM) and generalized additive mixed models (GAMM) in R v3.5.2 (R Core Team, 2018) using the packages lme4 v1.1-19 (Bates, Mächler, Bolker, & Walker, 2015) and mgcv 1.8-26 (Wood, 2011), respectively. GAMMs are a general form of GLMMs which can be used to model non-linear effects. The advantage of using GAMMs over the more standard polynomial GLMMs is that, while polynomial solutions are arbitrary, the smoothing functions in GAMMs are constrained and partially based on the data. GLMMs were selected over GAMMs in cases where we did not have reason to expect nonlinear effects.  $p$ -Values were obtained using  $t$ -tests with Satterthwaite's approximation to degrees of freedom on the individual terms through lmerTest v3.0-1 (Kuznetsova, Brockhoff, & Christensen, 2017; Luke, 2017) in the GLMMs, and by comparison of a model including the relevant term with one in which the term is dropped using the compareML() function in itsadug v2.3 (van Rij et al., 2017) in GAMMs. The specific predictors and outcome measures are reported below for each

analysis. In all GAM models a by-participant intercept was entered as a random effect. For the full specification of the models discussed in the article, see Supporting Information.

Our first set of analyses examines the frequency and development of infant-initiated triadic gestures from 10–12 months of age. We took frequency as our predictor variable as opposed to a binary distinction of presence or absence of the gesture since not all very early productions of gestures are intentionally communicative (see Carpendale & Carpendale, 2010) and reliance on a binary distinction may overestimate productive use of the gesture in question. Next, we investigated the two aspects of the maternal input over time; frequency of utterances, and frequency of contingent talk. Our final analysis examined the relationship between infant gestures and maternal input on vocabulary development (receptive and productive) at 12 and 18 months as measured by the self-report CDIs.

### *The Development of Reaches, HoGs, and Points From 10 to 12 months*

Figure 1 displays the frequency of reaches, HoGs, and points within each group. All three types of infant gesture were found in each of the groups. In order to ascertain whether infant use of the gestures varied across background and across time we fitted GAMMs with cultural group (Bengali, Chinese, English) and age (10, 11, 12 months) as predictors and each of the gestures as the outcome measure. Cultural group was not a significant predictor of the frequency of any of our target gestures (reaches:  $\chi(6) = 3.261$ ,  $p = .367$ ; HoGs:  $\chi(6) = 4.731$ ,  $p = .149$ ; points  $\chi(6) = 1.541$ ,  $p = .799$ ). Age was a significant predictor of HoG frequency ( $\chi(2) = 12.360$ ,  $p < .001$ ) and point frequency ( $\chi(2) = 4.585$ ,  $p = .01$ ), but not reach frequency ( $\chi(2) = 0.814$ ,  $p = .443$ ). Both HoGs and points increased in frequency over time by an estimate of 1 HoG/point every 2 months.

### *Maternal Production of Utterances and Contingent Talk Over Time*

Figures 2 and 3 displays the frequency of (a) maternal utterances and (b) contingent talk. We ran GAMMs with cultural group and age as predictors, one with maternal utterance frequency and one with maternal contingent talk frequency as the outcome measure. Neither cultural group nor infant age were significant predictors of maternal utterance frequency (cultural group:  $\chi(6) = 3.122$ ,



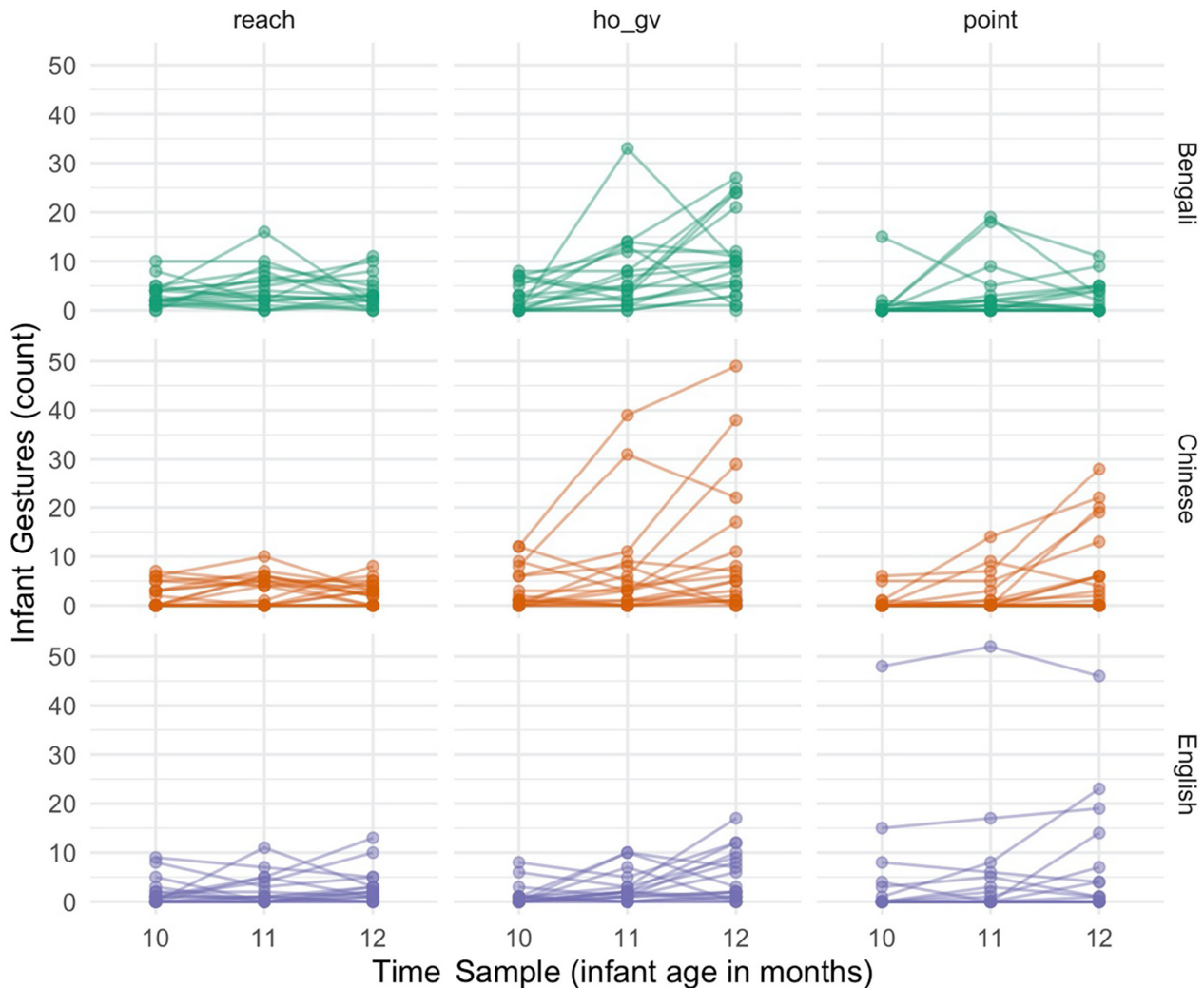


Figure 1. The frequency of infant reaches, holding out and giving gestures (ho\_gv), and points over time across the sample. [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

$p = .396$ ; infant age:  $\chi(2) = 2.545$ ,  $p = .078$ ). Age was significant for contingent talk frequency (i.e., caregivers produced more contingent talk over time), but not cultural group (cultural group:  $\chi(6) = 3.087$ ,  $p = .404$ ; infant age:  $\chi(2) = 4.425$ ,  $p = .012$ ), suggesting an increase in contingent talk over time in all three groups.

#### *The Relationship Between Reaches, HoGs, and Index Finger Pointing Gestures*

We investigated the extent to which HoGs and reaches predicted pointing frequency in the following recording sample. We ran a GLMM with cultural group, age and target gesture (i.e., HoG or reach) as predictors and pointing frequency in the following recording as the outcome measure. We

used the subsequent recording for the outcome measure in order to present a developmental, longitudinal approach to the analysis (i.e., to capture the relationship between the target gesture at, for example, 10 months and pointing at 11 months). There was a moderate positive effect of HoG frequency on pointing in the English sample where for every unit increase in HoG gestures pointing in the next visit increased by 1.25 ( $z = 2.106$ ,  $p = .035$ ). On the other hand, the count of reaches was not a significant predictor of subsequent pointing, nor was its interaction with cultural group.

#### *Predictors of Vocabulary Scores at 12 and 18 Months*

We investigated the effects of infant gestures, maternal utterances and contingent talk on both

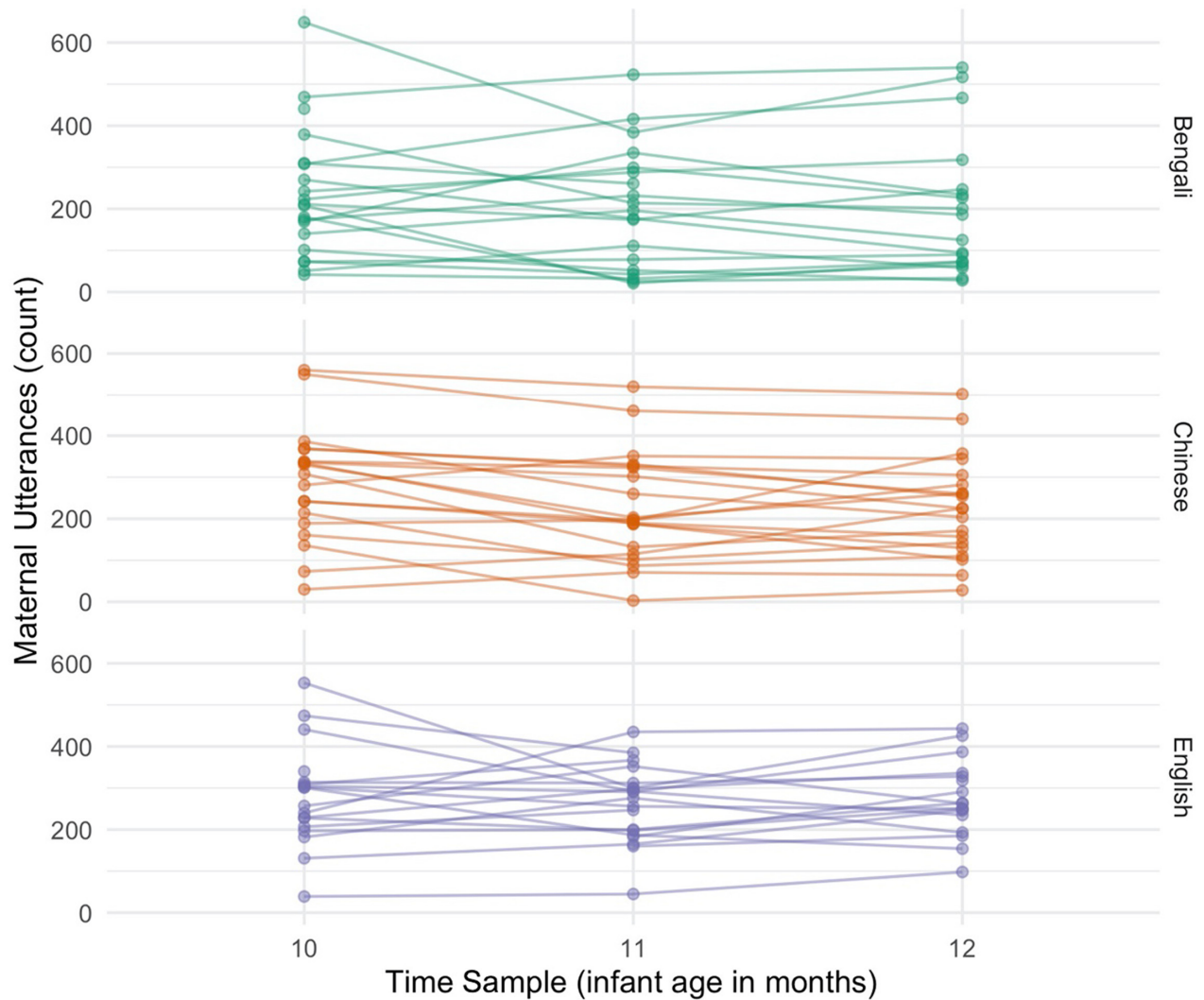


Figure 2. Frequency of maternal utterances within each cultural group. [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

vocabulary comprehension and production at 12 and 18 months. A single model including all predictors was attempted but due to the small sample size it suffered from irreparable issues of singularity and convergence, hence separate models testing individual predictors were run. We ran a series of GLMMs which investigated the effects of cultural group, age, frequency of the three infant gestures, frequency of maternal utterances and contingent talk on infant vocabulary comprehension and production at 12 and 18 months. To explore the combined and individual effects of each type of infant gesture frequency, we fitted three types of models: one with the total count of all the gesture types, one with the count of HoGs and points (to form one “declarative” category, in contrast to reaches which typically have an instrumental motivation;

see Salo, Rowe, & Reeb-Sutherland, 2018; Tamis-LeMonda, Song, et al., 2012), and one with the count of reaches only. Gestures were pooled across the three prelinguistic time samples due to the relatively low frequency of the behaviors. The effect of maternal utterance and maternal contingent talk frequency on vocabulary comprehension and production were also tested separately. Given the number of models and potential interactions, an overview of the results is presented here and we report only those terms for which the calculated *p*-value is smaller than 0.05 (see Supporting Information for details). Cultural group was coded as factor, with English as the reference level, so that the other groups could be compared to this one. Firstly, we present the results of the models predicting vocabulary comprehension and then the models

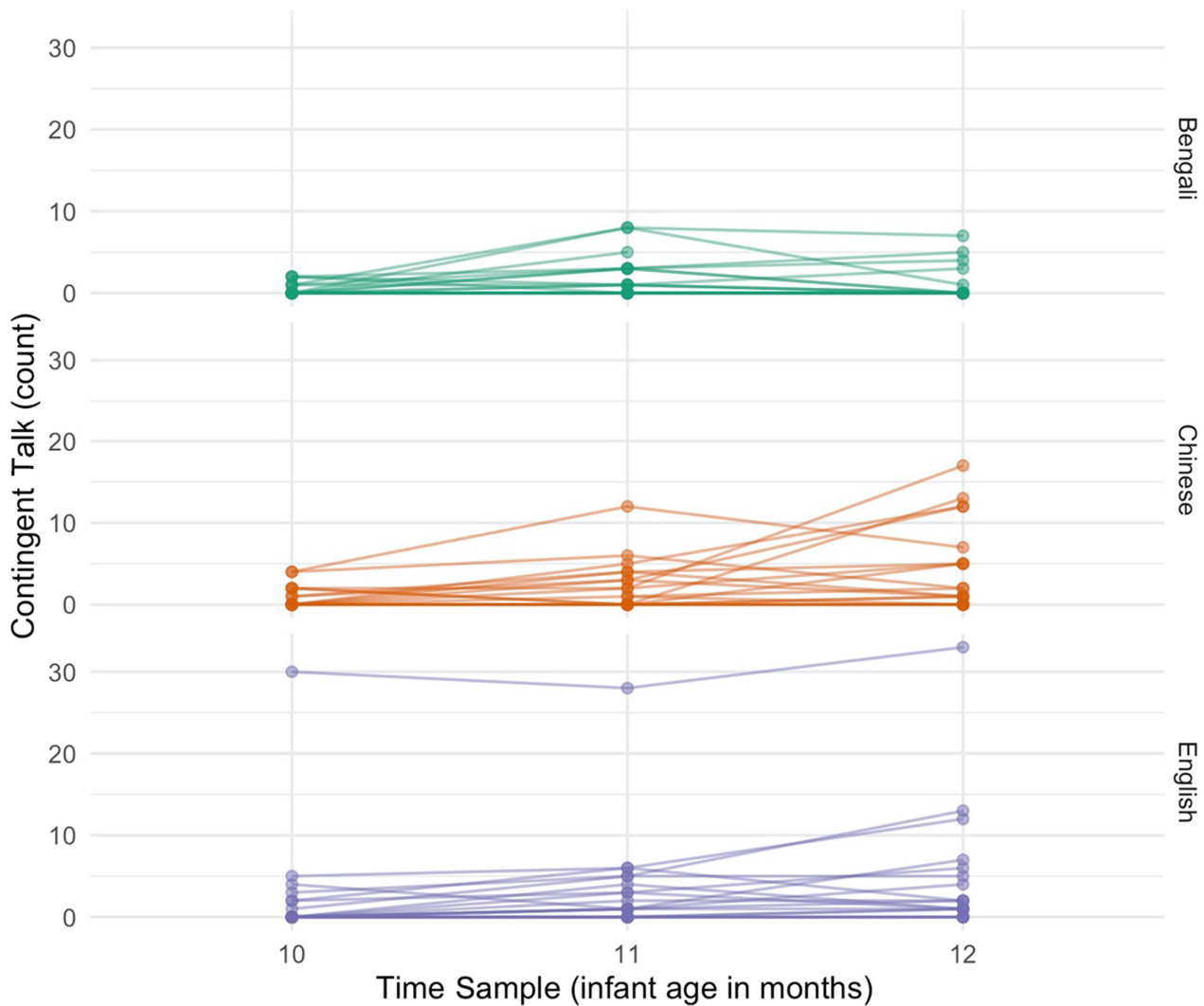


Figure 3. Frequency of maternal contingent talk. [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

predicting vocabulary production. Each model included a prelinguistic measure taken from the video-recorded parent–infant interaction taken between 10 and 12 months (i.e., gesture, number of maternal utterances, frequency of contingent talk), infant age, cultural group along with all logical two-way and three-way interactions as predictors of the vocabulary scores. A summary is provided in Table 2.

#### *Prelinguistic Gestures and Vocabulary Comprehension*

##### *All Gestures Combined*

Child age had a significant positive effect ( $\beta = 110.697$ ,  $SD = 30.293$ ,  $t = 3.654$ ,  $p = .0004$ ). Chinese children had a significantly lower average

comprehension score compared to the English children ( $\beta = -89.225$ ,  $SD = 35.939$ ,  $t = -2.483$ ,  $p = .0147$ ), and there was a significant interaction between the total count of gestures produced within the 10–12 month video-recorded interaction activities and Chinese infants comprehension score ( $\beta = 2.535$ ,  $SD = 0.733$ ,  $t = 3.457$ ,  $p = .0008$ ). All other terms and interactions did not reach significance.

##### *Hog + Points Only*

Again, there was a significant difference in average comprehension scores between infants at age 12 versus 18 months ( $\beta = 114.951$ ,  $SD = 28.455$ ,  $t = 4.040$ ,  $p = .0001$ ) and a significant interaction between total count of gestures (this time HoG and points) and Chinese infants comprehension score

Table 2  
Summary of Models

	All gestures			HoG + point			Reaches			Maternal utterances			Contingent talk							
	B	SE	t	p	B	SE	t	p	B	SE	t	p	B	SE	t	p				
Comprehension																				
Count	-0.38	0.43	-0.88	.38	-0.40	0.44	-0.90	.37	0.58	2.73	0.21	.83	-0.11	0.08	-1.32	.19	-1.39	2.72	-0.51	.61
Age = 18 months	110.70	30.29	3.65	.00	114.95	28.46	4.04	.00	136.35	36.43	3.74	.00	171.13	97.45	1.76	.08	106.39	36.22	2.94	.00
Background = Bengali	7.28	41.34	0.18	.86	0.57	37.26	0.02	.99	34.57	44.13	0.78	.44	-101.56	75.35	-1.35	.18	-14.84	33.88	-0.44	.66
Background = Chinese	-89.23	35.94	-2.48	.01	-63.18	32.50	-1.94	.05	-31.98	42.34	-0.76	.45	-136.00	79.67	-1.71	.09	-32.70	38.36	-0.85	.40
Count × Age (18 months)	0.70	0.61	1.14	.26	0.72	0.62	1.15	.26	-0.57	3.85	-0.15	.88	-0.07	0.11	-0.58	.56	3.45	3.85	0.90	.37
Count × Background (Bengali)	0.07	0.91	0.07	.94	0.27	1.05	0.26	.80	-2.72	3.88	-0.70	.49	0.13	0.09	1.46	.15	5.99	5.00	1.20	.23
Count × Background (Chinese)	2.54	0.73	3.46	.00	2.37	0.75	3.16	.00	4.70	4.29	1.09	.28	0.17	0.09	1.76	.08	5.58	3.78	1.48	.14
Age (18 months) × Background (Bengali)	-48.88	58.76	-0.83	.41	-48.18	52.98	-0.91	.37	-58.44	62.58	-0.93	.35	-84.51	107.80	-0.78	.44	-6.32	48.28	-0.13	.90
Age (18 months) × Background (Chinese)	10.53	51.16	0.21	.84	6.13	46.29	0.13	.89	-9.82	60.06	-0.16	.87	-48.28	113.84	-0.42	.67	8.49	54.57	0.16	.88
Count × Age (18 months) × Background (Bengali)	0.01	1.29	0.00	1.00	0.09	1.49	0.06	.95	1.61	5.49	0.29	.77	0.08	0.13	0.59	.55	-6.06	7.07	-0.86	.39
Count × Age (18 months) × Background (Chinese)	-0.65	1.04	-0.63	.53	-0.65	1.07	-0.61	.54	0.16	6.07	0.03	.98	0.07	0.13	0.49	.63	-2.57	5.35	-0.48	.63
Production																				
Count	0.06	0.28	0.20	.84	0.03	0.29	0.11	.91	0.76	1.84	0.41	.68	0.01	0.05	0.12	.90	0.58	1.54	0.38	.71
Age = 18 months	20.75	19.80	1.05	.30	27.82	18.54	1.50	.14	67.13	24.55	2.74	.01	26.71	58.99	0.45	.65	19.08	20.54	0.93	.36
Background = Bengali	1.83	27.02	0.07	.95	0.76	24.27	0.03	.98	5.13	29.73	0.17	.86	2.34	45.62	0.05	.96	-0.51	19.22	-0.03	.98
Background = Chinese	-5.84	23.49	-0.25	.80	-5.89	21.17	-0.28	.78	-3.83	28.53	-0.13	.89	1.13	48.23	0.02	.98	-4.70	21.76	-0.22	.83
Count × Age (18 months)	1.19	0.40	2.97	.00	1.23	0.41	3.01	.00	-1.23	2.60	-0.48	.64	0.02	0.07	0.25	.80	4.90	2.19	2.24	.03
Count × Background (Bengali)	-0.07	0.60	-0.11	.91	-0.04	0.68	-0.06	.95	-0.79	2.61	-0.30	.76	0.00	0.06	0.05	.96	0.61	2.83	0.21	.83
Count × Background (Chinese)	-0.01	0.48	-0.01	.99	0.00	0.49	0.00	1.00	-0.37	2.89	-0.13	.90	0.00	0.06	-0.07	.95	-0.29	2.14	-0.14	.89
Age (18 months) × Background (Bengali)	14.62	38.40	0.38	.70	10.49	34.52	0.30	.76	-42.73	42.17	-1.01	.31	-36.72	65.26	-0.56	.58	-18.49	27.39	-0.68	.50
Age (18 months) × Background (Chinese)	-38.76	33.44	-1.16	.25	-27.09	30.16	-0.90	.37	-61.98	40.47	-1.53	.13	12.48	68.92	0.18	.86	8.14	30.95	0.26	.79
Count × Age (18 months) × Background (Bengali)	-1.25	0.84	-1.48	.14	-1.41	0.97	-1.46	.15	2.00	3.70	0.54	.59	0.06	0.08	0.73	.47	5.70	4.01	1.42	.16
Count × Age (18 months) × Background (Chinese)	0.40	0.68	0.58	.56	0.19	0.69	0.28	.78	6.01	4.09	1.47	.15	-0.01	0.08	-0.15	.88	-2.50	3.03	-0.82	.41

( $\beta = 2.375$ ,  $SD = 0.752$ ,  $t = 3.158$ ,  $p = 0.002$ ), but the average difference between Chinese and English infants did not reach significance in this model.

#### *Reaches Only*

The only predictor that reached significance in this model was the infant age, and as in the above models comprehension scores were higher at 18 months ( $\beta = 136.348$ ,  $SD = 36.431$ ,  $t = 3.743$ ,  $p = .0003$ ).

#### *Maternal Speech, Contingent Talk, and Vocabulary Comprehension*

The following models are based on frequency counts of maternal speech and contingent talk produced during the 10–12 month video recordings and CDI comprehension measures at 12 and 18 months.

#### *Number of Maternal Utterances*

No predictor in this model was significant.

#### *Frequency of Contingent Talk*

Only infant age was significant with relatively higher score of comprehension at 18 months ( $\beta = 106.394$ ,  $SD = 36.217$ ,  $t = 2.938$ ,  $p = .004$ ).

#### *Summary*

In summary, the main pattern identified by the models related to a relative increase in comprehension scores at 18 months as compared to 12 months. Overall gesture frequency and also HoG + point gesture frequency also appeared to have an effect on comprehension scores within the Chinese infant group only. We did not detect an effect of either of the maternal measures on vocabulary comprehension.

#### *Prelinguistic Gestures and Vocabulary Production*

##### *All Gestures Combined*

Vocabulary production scores at 18 months were positively correlated with gesture count at 10–12 months (interaction Gesture Counts  $\times$  Infant Age  $\beta = 1.191$ ,  $SD = 0.400$ ,  $t = 2.973$ ,  $p = .0037$ ).

##### *Hog + Points Only*

Vocabulary production scores at 18 months were positively correlated with gesture count (HoG and

points) at 10–12 months (interaction Gesture Counts  $\times$  Infant Age  $\beta = 1.226$ ,  $SD = 0.407$ ,  $t = 3.012$ ,  $p = .003$ ).

#### *Reaches Only*

Vocabulary production scores were significantly higher at 18 months ( $\beta = 67.126$ ,  $SD = 24.547$ ,  $t = 2.735$ ,  $p = .0074$ ). There was no indication of a significant effect of reaches and cultural group based on the individual predictions and interactions thereof.

#### *Maternal Speech, Contingent Talk, and Vocabulary Production*

The following models are based on frequency counts of maternal speech and contingent talk produced during the 10–12 month video recordings and CDI production measures at 12 and 18 months.

#### *Number of Maternal Utterances*

No predictor in this model was significant.

#### *Frequency of Contingent Talk*

There was a significant interaction between contingent talk count and production score at 18 months (CT Count  $\times$  Infant's Age  $\beta = 4.898$ ,  $SD = 2.186$ ,  $t = 2.241$ ,  $p = .0273$ ).

#### *Summary*

In summary, the models suggest that the predictors of infant gestures counts combined, HoG + point counts, and maternal contingent talk have an effect on vocabulary production at 18 months.

## Discussion

In this study, we investigated the development of prelinguistic communicative gestures and interaction, and their relationships with subsequent vocabulary development across three distinct cultural groups in the United Kingdom. Our key findings are as follows. First, all three target prelinguistic gestures (reaches, HoGs, and points) were attested in all groups and the frequency of HoGs, and points, but not reaches, increased in frequency over time. Second, we found that the frequency of contingent talk increased in all groups over time and

that there were no significant group differences in the amount of maternal speech or contingent talk. Finally, we identified a positive relationship between infant gestures combined, HoG and pointing gestures, and contingent talk on vocabulary production at 18 months. In general, we did not detect differences between the three cultural groups with two exceptions; HoG frequency predicted pointing only in the English sample, and gesture frequency combined and HoG + pointing frequency only, had a positive relationship with vocabulary comprehension in the Chinese group only. In the following section we discuss each of our key findings in turn.

Our study provides support for the universal nature of prelinguistic communicative gestures and adds to the literature by demonstrating that HoGs as well as points and reaches are found in different cultural groups (e.g., Callaghan et al., 2011; Salomo & Liszkowski, 2013) and that HoGs, like points increased in frequency in some infants over development though at a relatively low rate (though this may be a reflection of task length). This trend indicates that HoGs may have developmental significance in early communicative development (see also Cameron-Faulkner et al., 2015). We did not detect any cultural differences in the frequency of our target gestures and in this respect our findings matched our expectations. In this regard our findings reflect those of Callaghan et al., (2011) who concluded that there was clear cross-cultural similarity in pointing frequency at 12 months in their three target groups (rural Canada, Peru, India). Interestingly, though, the authors note that significantly fewer Indian infants pointed than in the other two groups but suggest that this difference could be due to the smaller number of objects used in the pointing task with this particular group or to apparent lower levels of education within the group, as opposed to developmental differences in pointing production. Our findings, however, contrast with those of Salomo and Liszkowski (2013) who found significant differences in gesture frequency (and also type) within their Yucatec-Mayan, Dutch, and Shanghai-Chinese infants. A key difference between the studies suggestive of cultural similarity and that of Salomo and Liszkowski (2013) is the form of data collection, with the former studies using a semi-structured task and the latter using naturalistic observations of daily activities. Together these two approaches indicate that when parents and infants are placed in a similar context, the forms of interaction will also be similar, but that in daily life these behaviors may be more or less apparent as consequence of cultural factors.

We did not identify any differences in the number of utterances produced over time and between the cultural groups. Our findings reflect those of Tamis-LeMonda, Song, et al. (2012) who also found no difference in the overall amount of talk produced by mothers in their three cultural groups (Mexican, Dominican, African American), though they did find differences in the type of talk (i.e., regulatory vs. referential), a factor not investigated in this study. We did find that the amount of contingent talk increased over time and suggest two possible explanations for the pattern. First, it may be the case that the mothers produced more contingent talk as their infants displayed more interest in triadic interaction over developmental time. An alternative, more direct hypothesis is that the increased number of gestures produced by the infants provided more opportunities for the production of contingent talk. To some extent both explanations tap into the same underlying construct, that is, the centrality of meaningful interaction in the behaviors produced by both caregiver and infant throughout development. In contrast to our expectations, we did not detect an effect of cultural background on either of our maternal language measures. However, as Salomo and Liszkowski (2013) suggest, it is likely that cultural differences in all aspects of prelinguistic interaction would be more apparent during everyday activities as opposed to in an (albeit informal) elicitation task such as the one used in this study.

In keeping with a number of studies, our findings show a relationship between prelinguistic gesture, interaction, and early vocabulary development (e.g., Colonnese et al., 2010; Lüke et al., 2017; Rowe, Özçalışkan, & Goldin-Meadow, 2008; Salo et al., 2018). Positive relationships were found between gesture use (though notably with the exception of reaches) between 10–12 months and vocabulary production at 18 months. Our findings therefore support previous work indicating the preferential status index finger points and HoGs over reaches on language development (e.g., Butterworth, 2003; Camaioni, 1993). Index finger pointing and HoGs gestures are claimed to be more cognitively complex than reaching gestures as they require the infant to have some understanding of the cognitive effects of their actions on others (e.g., Tomasello, 1999) and therefore provide infants with a practice ground for the subsequent emergence of language. In terms of the relationship between HoG and points, we only found a positive relationship in the English sample and so the data provide limited support for claims that these early communicative

gestures have developmental significance for the emergence of index finger pointing (e.g., Bates et al., 1975; Boundy, Cameron-Faulkner, & Theakston, 2019; Cameron-Faulkner et al., 2015). It is possible that these findings indicate cultural differences, however, a word of caution in interpreting the results of these models is in order, due to low statistical power. Future work is necessary to establish whether the patterns observed here can be replicated and whether cultural differences can be detected.

We did not detect any robust patterns with regard to gesture use and comprehension scores at either age or production scores at 12 months. We suggest that the very low scores found in the vocabulary production measures at 12 months may account for the lack of association, but the findings in terms of comprehension scores are more difficult to explain. In their meta-analysis, Colonnese et al. (2010) found that both production and comprehension scores were equally associated with rates of infant pointing (see also McGillion et al., 2017). We did find a positive association between gesture use in our Chinese sample at both 12 and 18 months and interestingly this relation was found only in the models of all gestures combined and HoG + point models (i.e., not the reaches only model). Furthermore, we also found that the Chinese infants had a lower comprehension score than the English infants. Again, our study comes with the caveat that future work is necessary to establish whether the patterns observed here reflect true cultural differences and the use of non-normed CDIs requires this finding to be interpreted with caution.

Our study also reflects current literature in terms of the positive relationship between maternal contingent talk and vocabulary development. The amount of contingent talk produced during prelinguistic development predicted vocabulary production at 18 months. The role of contingent talk highlights the importance of social interaction during prelinguistic development and early language development (e.g., Carpenter et al., 1998; Huttenlocher et al., 1991; McGillion et al., 2017; Tamis-LeMonda, Song, et al., 2012; Tomasello & Farrar, 1986). Through engaging and responding with their infants' communicative bids, the caregiver ascribes meaning to the infant behaviors. In our study, mothers from all three cultural groups engaged in this form of "meaning making" and viewed their infants' gestures as communicative and worthy of response. From a dynamic, social-constructivist/process-based approach to development, the propensity of caregivers to respond to their infants'

gestures as meaningful provides a clear signal to the infant that their gestures are communicative as well providing the rich linguistic input necessary for language development. Overall our findings confirm those of previous studies which suggest that the interactional and cognitive processes necessary for vocabulary development are apparent in the prelinguistic stage. Through drawing co-participants' attention to objects and events of interest, infants are developing the skills necessary for the development of referential language (Bates et al., 1975; Carpenter et al., 1998; Liszkowski, 2005; Matthews, Behne, Lieven, & Tomasello, 2012; Rodríguez, Moreno-Núñez, Basilio, & Sosa, 2015; Werner & Kaplan, 1963).

Our study comes with some limitations. Our decision to use a semi-structured elicitation task comes at the cost of cultural authenticity; we provide analyses of how caregivers and infants from three communities interact during standardized activities but we cannot speak to the issue of how frequently these gestures and behaviors occur in normal daily life. Furthermore, given the relatively low frequency of the infant gestures (even within a standardized task) we were not able to investigate the relationship between gesture type and frequency of maternal contingent talk. Also, as we did not independently assess the level of acculturation of the Bengali-speaking and Chinese-speaking mothers, we cannot be sure of the extent to which the dyads were affected by the norms of the host British culture (though given the mothers' low proficiency in English we suspect that acculturation levels were low). Relatedly, the use of modified versions of the CDIs also carried assumptions about levels of acculturation. While the CDIs were piloted on members of our target population, more work is needed to create normed, standardized version of these tools for use with minority ethnic populations.

Finally, although the sample size is comparable to many studies focusing on the development of prelinguistic gestures (e.g., Callaghan et al., 2011), it has an exploratory status with regards to the relationship between prelinguistic and early language development. The families included in our analysis comprise a hard to reach sample and as a consequence required considerable recruitment resources. The ethnic minority mothers in our sample did not attend the usual play groups and venues that many studies recruit from and the most effective manner of recruitment was through word of mouth via key members of the target communities. The underrepresentation of our target groups in these standard settings is in itself a key indicator of the lack of



diversity not only in our research, but in the daily life of our urban communities.

This study is one of a number of studies which aims to widen the scope of communication development research to encompass cultures beyond the WEIRD. To date, to our knowledge, there are no cross-cultural studies of prelinguistic development and its relationship with early language development within European nations despite their cultural diversity. Instead most research emphasis on non-English speaking ethnic minority groups is placed on school readiness (see Whiteside, Gooch, & Norbury, 2017) and on the identification of developmental language disorder (Stow & Dodd, 2003). It is clear that much of the groundwork in terms of language occurs years before children enter formal schooling and therefore it is imperative that wealthy culturally diverse nations such as the United Kingdom make every attempt to understand the dynamics of development in infants from a range of cultural backgrounds. However, as Bornstein et al. (2012) point out, it is also important to avoid normalizing the behaviors of the majority culture and to assume that it is desirable for all groups to assimilate the majority culture practices. In order to fully understand the intricate relationship between prelinguistic interaction and language development it is essential to study communicative behaviors and interactions “in the round” as opposed to through the lens of a western model of “typical” development.

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### Supporting Information

Additional supporting information may be found in the online version of this article at the publisher's website:

#### Appendix S1. Statistical Analysis