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Cross-cultural evidence for multimodal motherese: Asian Indian mothers' adaptive use of synchronous words and gestures

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ABSTRACT

In a quasi-experimental study, 24 Asian Indian mothers were asked to teach novel (target) names for two objects and two actions to their children of three different levels of lexical mapping development: prelexical (5–8 months), early lexical (9–17 months), and advanced lexical (20–43 months). Target naming (n = 1482) and non-target naming (other, n = 2411) were coded for synchronous spoken words and object motion (multimodal motherese) and other naming styles. Indian mothers abundantly used multimodal motherese with target words to highlight novel word–referent relations, paralleling earlier findings from American mothers. They used it with target words more often for prelexical infants than for advanced lexical children and to name target actions later in children's development. Unlike American mothers, Indian mothers also abundantly used multimodal motherese to name target objects later in children's development. Finally, monolingual mothers who spoke a verb-dominant Indian language used multimodal motherese more often than bilingual mothers who also spoke noun-dominant English to their children. The findings suggest that within a dynamic and reciprocal mother–infant communication system, multimodal motherese adapts to unify novel words and referents across cultures. It adapts to children's level of lexical development and to ambient language-specific lexical dominance hierarchies.

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Introduction

Caregivers' infant-directed communication is multisensory and contains a wide array of auditory, visual, and sometimes even tactile information (see reviews by Jouanjean-L'Antoune, 1997; Massaro, 2004). Caregiver naming in particular typically conveys coordinated temporal information that scaffolds infants' attention to otherwise arbitrarily related words and referents. In Western cultures, mothers name objects and actions and simultaneously use "showing" gestures as they move objects in their infants' line of sight (Masur, 1997; Messer, 1978; Zukow-Goldring, 1997). During naming of objects and actions in close proximity to their infants, mothers sometimes also touch the infants with an object they are holding. This synchronous auditory, visual, and sometimes tactile naming is called *multimodal motherese* (Gogate, Bahrick, & Watson, 2000). Cross-cultural studies of infant-directed multisensory communication could further underscore its diversity, salience, and role in infants' perception, attention, and initiation into the world of communication. In the current cross-sectional study, we examined whether multimodal motherese is a widespread naming style that highlights novel word–referent relations for infants.

Gogate and colleagues (2000) found empirical evidence for a dynamic and adaptive mother–infant communicative system that promotes word learning. Caucasian and Hispanic American mothers were asked to teach the names of two novel objects and actions. Mothers of *prelexical infants* (5–8 months) taught novel words by spontaneously using multimodal motherese more often when naming target referents (names they were asked to teach their infants) than non-target referents, suggesting that multimodal motherese highlights novel word–referent relations. Preverbal infants are typically unable to learn novel word–referent relations without such highlighting (Gogate, 2010; cf. Fulkerson & Waxman, 2007). For example, 7- and 8-month-old infants failed to learn such relations when the syllables were spoken out of phase with object motions (Gogate, 2010). Multimodal motherese is not restricted to explicit teaching contexts (Björkenstam & Wiren, 2012; Tamis-LeMonda, Song, Smith Leavell, Kahana-Kalman, & Yoshikawa, 2012). Caucasian and Hispanic American mothers naturally use multimodal motherese during play with their 6- to 8-month-old infants, using toys even when not explicitly asked to teach names for novel objects (Gogate, Maganti, & Laing, 2013).

In addition, mothers promote their children's lexical learning by tailoring their use of synchrony to their children's level of lexical development. Gogate and colleagues (2000) found that Caucasian and Hispanic American mothers of prelexical infants (5–8 months) used synchrony more often than mothers of *lexically advanced* children (21–30 months). Furthermore, mothers used synchrony during action naming much later in development for *early lexical* infants and toddlers (9–17 months). In contrast, mothers' synchrony use during object naming declined from the prelexical period to the early lexical period. Together, these findings raise the question as to whether mothers' tailoring of multimodal motherese to their children's lexical development and to different lexical categories is a cross-cultural phenomenon-. More evidence is needed to address whether Gogate and colleagues' earlier findings generalize to non-Western cultures.

Cross-cultural examinations are essential for understanding the underlying mechanisms by which multimodal motherese orients infants throughout the world to communicating adults. One way in which it orients preverbal infants is by scaffolding their joint attention. When American mothers named objects while moving them in synchrony more often during play with their 6- to 8-month-olds, a greater number of infants switched gaze from their mothers to the objects and learned the word mappings, indexed on a post-play test (Gogate, Bolzani, & Betancourt, 2006). For the word mapping novice (preverbal infant), the repeated use of synchrony between the spoken word and the 'showing' gesture (i.e., looming or shaking but not sideway or upward motion) with an object unified the word and the object, making that relation *perceptually foreground* while rendering other potential referents that are not moved to the background (Gogate et al., 2006; Matatyaho & Gogate, 2008; Matatyaho-Bullaro, Gogate, Mason, Cadavid, & Abdel-Mottaleb, 2014). Thus, synchrony narrowed the potential referents for a given name. On hearing a word from their mothers, young infants responded to the mothers' synchronous 'showing' gesture with an object by switching their gaze to it and learning the novel word–referent relation (Gogate et al., 2006). Preverbal infants remember syllable–object

relations learned in the presence of synchrony up to 4 days after original learning (Gogate & Bahrick, 2001), suggesting that this learning is robust.

Cross-cultural research has revealed universal properties and variations in several acoustic and visual features of multimodal infant-directed speech and facial gestures (e.g., Fernald & Morikawa, 1993; Masataka, 1992) and infants' enhanced attention to these features (Bahrick & Pickens, 1988; Kim & Johnson, 2014; Werker, Pegg, & McLeod, 1994). To date, however, we do not know whether multimodal motherese, the synchronized naming and moving of objects to highlight word–referent relations, is widespread and whether mothers in non-Western cultures tailor their naming style to their children's level of lexical development as they do in Western cultures. Barring a few studies of Japanese mothers' labeling to 2-year-olds (Imai & Gentner, 1997; Kobayashi, 1997; Yoshida, 2012), investigations of maternal labeling to infants and young children are primarily restricted to Western populations (Gogate et al., 2000; , 2006, 2013; Masur, 1997; Messer, 1978; Zukow-Goldring, 1997; see also Tamis-LeMonda et al., 2012). Of the studies of Japanese mothers' labeling to their toddlers, only one reports that mothers synchronize their verb naming with their actions (Yoshida, 2012), but not whether mothers tailor its use to their toddlers' lexical development. Consequently, we are as yet unable to ascertain whether multimodal motherese and its tailoring to children's lexical development found in Western populations can be generalized to non-Western populations.

Prior to generalizing about multimodal motherese, empirical investigations are warranted because caregivers' communication varies across cultures in their gestures, vocal emotion, and speech (Bornstein et al., 1992; Masataka, 1992; Tamis-LeMonda et al., 2012). For example, mothers from the Kaluli of New Guinea (Scheiffelin, 1979) and the Kwara'ae of the Solomon Islands (Watson-Gegeo & Gegeo, 1986) do not directly speak or engage in face-to-face play with their infants. Instead, they use a high-pitched voice to address a third person on behalf of their infants, with the infants turned toward and facing the third person. Thus, it is possible that mothers from some cultures neither name objects and actions as do Western mothers nor use multimodal motherese to highlight novel word–referent relations for their infants. Furthermore, cross-cultural variations in caregivers' communication yield matching variations in infants' language comprehension. For example, Indian mothers used directives predominantly containing verbs such as "give" and "take" more often than British mothers to their 6.5- to 12.5-month-olds, suggesting verb dominance. Reciprocally, Indian infants complied with their mothers' directives more often than British infants and at an earlier age, showing greater verb comprehension (Reddy, Liebal, Hicks, Jonnalagadda, & Chintalapuri, 2013). Given these variations, we cannot assume that multimodal motherese is a cross-cultural phenomenon-without further empirical investigation.

The linguistic environment of infants in urban India is rather unique and makes a good case for empirically examining the universal properties and culture-specific variations in multimodal motherese. Indian mothers (who are high school graduates) have a working knowledge of spoken and written English and may use it selectively at home, at work, or if spoken to in English in addition to one or more Indian languages. Therefore, infants are exposed, at a minimum, to one of many verb-dominant Indian languages and noun-dominant English in varying proportions, based on maternal openness to Western influences.[1] The differing lexical dominance hierarchies should result in variations in maternal noun versus verb use to infants. This in turn could yield corresponding variations in maternal use of multimodal motherese to highlight noun–object versus verb–action relations to infants, especially because it scaffolds infants' attention to word–referent relations. Given that referents for verbs are far more fleeting and intangible than referents for nouns (Gentner, 1982; McDonough, Song, Hirsh-Pasek, Golinkoff, & Lannon, 2011), Indian mothers might use more scaffolding when speaking a verb-dominant Indian language than noun-dominant English.

The cross-study evidence suggests that variations in lexical dominance hierarchies yield matching variations in children's language and in caregivers' communication within an interactive mother–infant communication system (Kim, McGregor, & Thompson, 2000). For example, infants who learn a noun-dominant language produce object names earlier and more often than action names

[1] In urban India, English is spoken within the home owing to India's British colonial legacy, enhanced more recently by the mass media, the internet, and global economic trends. English, the prestige language and medium of instruction in secondary and higher education, is also widely used in urban preschool and elementary instruction.

(Nelson, Hampson, & Shaw, 1993; Tomasello, Akhtar, Dodson, & Rekau, 1997). Mothers compensate for infants' lag in action names. They use synchrony much later in development when naming actions than objects (Gogate et al., 2000). In contrast, infants who learn a verb-dominant language produce action names earlier than object names (Choi, 1998; Tardiff, 1996; Yoshida, 2004). Adults and children who learn verb-dominant languages produce fewer object names than action names (e.g., as in Tamil, an Indian language; Sethuraman & Smith, 2010). Therefore, in our view, noun versus verb dominance is a bidirectional language-specific phenomenon- observable in children's and caregivers' language. Multiple factors manifest as noun or verb dominance in a language, including word frequency in maternal input, cultural practices that guide topics of maternal conversations to children, the number and type of inflections in the verb versus noun system of the language, and children's frequency of noun versus verb production. Given the greater difficulty in learning the more frequent verb–action relations when learning a verb-dominant language, Indian infants likely need a great deal more scaffolding to attend to and learn them in spite of early exposure to verb–action relations. To match this need, Indian mothers might use synchrony more often and later in children's development to highlight novel verb–action relations compared with American mothers (Gogate et al., 2000). In addition, verbs cannot be taught without demonstrating an action. Thus, action naming might naturally entail object motion synchronous or asynchronous with a spoken word relative to object naming.

In the current study, we hypothesized generally that multimodal motherese is a widespread naming style that highlights novel word–referent relations for infants across cultures. Alternatively, cross-cultural examinations might reveal that multimodal motherese is a specific characteristic of Western mothers' naming to infants and young children (as in Gogate et al., 2000). Similar to Gogate and colleagues (2000), mothers were asked to teach their child novel (target) names for two objects and actions during a play episode. This naming was compared with mothers' naming of other objects and actions on the scene. We had four specific hypotheses, three of which were similar to those of Gogate and colleagues (2000).

First, we hypothesized that if synchrony highlights novel word–referent relations across cultures, then Indian mothers, like Western mothers (e.g., Gogate et al., 2000), should use it more often than other naming styles (e.g., naming a static object) when naming target referents, to highlight the word–referent relations they are asked to teach, than when naming non-target referents.

Second, we hypothesized that maternal naming style interacts with children's level of lexical mapping development, paralleling the findings of Gogate and colleagues (2000). Thus, mothers of prelexical infants (5–8 months) should use synchrony between spoken words and object motion more often to highlight novel word–referent relations than mothers of lexically advanced children (>20 months). Prelexical infants, who are in the early stages of learning to put words and referents together, would benefit from greater maternal perceptual highlighting using synchrony (Gogate, 2010; Gogate et al., 2006). Their mothers should name novel referents in the presence of a static object less often because it does not highlight word-referent relations and impedes their learning of syllable–object mappings (Gogate & Bahrick, 1998, 2001). In contrast, mothers of early lexical and lexically advanced children should name novel referents in the presence of a static object more often. Their lexical advancement may reduce the need for maternal scaffolding to map novel words onto referents. Alternatively, owing to the greater difficulty in learning fleeting verb–referent relations in a verb-dominant first language, Indian infants might benefit from a great deal more scaffolding to learn these relations relative to infants learning a noun-dominant language (e.g., English). Reciprocally, Indian mothers should use synchrony to highlight verb–referent relations early on and until much later in children's development compared with American mothers (Gogate et al., 2000).

Next, we hypothesized that, adapting to the lexical dominance hierarchy of languages, the monolingual Indian mothers, who speak a verb-dominant Indian language, would use multimodal motherese to highlight novel verb–action relations more often than bilingual mothers who speak an Indian language and noun-dominant English. The monolingual mothers should use multimodal motherese more often to highlight the greater number of fleeting verb–action relations for their children. These hypotheses, if supported, would provide cross-cultural evidence for ongoing interaction between maternal naming and children's lexical mapping development in a dynamic mother–infant communication system (Gogate & Hollich, 2010, 2013; Gogate, Walker-Andrews & Bahrick, 2001). Our goal was to elucidate this interaction and assess the culture-specific variations in Indian mothers' multimodal motherese.

Finally, we hypothesized that if multimodal motherese highlights novel word–referent relations, then Indian mothers should use trimodal (auditory–visual–tactile) synchrony more often when naming novel referents (using target words) than other referents (using non-target words), similar to American mothers (Gogate et al., 2000).

Method

Participants

The final sample consisted of 24 healthy mothers and their children (13 female and 11 male). Each child belonged to one of three age groups that represented three levels of lexical mapping development: prelexical, early lexical, and advanced lexical (Gogate et al., 2000). Prelexical infants (5–8 months), who are starting to learn novel word–referent relations (Bergelson & Swingley, 2012; Tincoff & Jusczyk, 2011), need a great deal of assistance to put words and referents together and do not as yet say words (Fenson et al., 1994). Early lexical infants (9–17 months) need less assistance to learn novel word–referent relations. They understand and begin to produce words at a steady rate (Fenson et al., 1994). Advanced lexical children (20–43 months) learn novel word–referent relations easily and can fast map, which is evident in their burgeoning vocabulary (Fenson et al., 1994). These well-established lexical mapping norms by children's age were used (in lieu of a standardized language assessment) to examine mothers' naming style adaptations, the main focus of the current study. Furthermore, although the final sample consisted of a small number ($n = 8$) of mother–child dyads in each of the three groups, the number of data points obtained from the dyads was large (see Table 1 in Results). The use of a large number of data points from a small number of dyads reduces between-participants variability, consistent with contemporary designs for the study of maternal language (e.g., Gogate et al., 2000; Reddy et al., 2013; Yu & Smith, 2012).

The mothers and children resided in middle-income suburbs of Bangalore, a large metropolis in Southern India. Of the 24 mothers, 9 were college graduates, 2 had completed 3 years of college, and 13 had completed high school. The mothers could read and write English. The children were born to term and had no history of medical complications prior to, during, or after birth. An additional 5 dyads were excluded from the final sample because the child was fussy ($n = 1$) or born preterm ($n = 1$), the mother did not complete high school ($n = 1$), or there was external interference ($n = 2$).

Stimuli

The stimuli were identical to those used by Gogate and colleagues (2000). The two toy objects, a Martian and a raccoon made of cloth, were named "gow" and "chi." The two action names were "pru," depicting a leaping action performed with a stuffed teddy bear, and "flo," depicting a shaking action performed with a stuffed fish (Fig. 1). The actions were similar to other actions that parents would naturally perform with objects for their infants (Gogate et al., 2013; Matatyaho & Gogate, 2008). The words were in mothers' phonotactic repertoire; they knew English and at least one Indian language. Mothers reported that their children had no prior knowledge of the target words via a questionnaire.

Procedure

Mothers and children were recruited during well-child visits to a pediatric clinic. Informed consent was obtained prior to participation as per the institutional review boards of Florida International University and SUNY Health Science Center at Brooklyn. All mothers provided written consent in English, and participated with their children prior to their medical exam, in a room adjacent to the pediatrician's examination room.

Similar to Gogate and colleagues (2000), mothers were taught the novel (target) names for two actions and two objects prior to play with their children. The experimenter (first author) first named the two objects, "gow" and "chi," and demonstrated and named the two actions, "pru" and "flo," to each mother in her child's absence (Fig. 1). To elicit mothers' spontaneous use of synchronous (or asynchronous) naming, the experimenter named neither objects nor actions while moving the paired object.

Fig. 1. The object and action names that mothers taught during semi-structured play (reprinted with permission; Gogate et al., 2000).

Next, mothers sat cross-legged on a bed sheet spread on a floor, facing their infants or toddlers, who were seated in infant seats; older children sat directly on the bed sheet facing their mothers. A camera (Sony DSR-PD170) was positioned on one side of the mothers and children. Both were in the camera's visual field during the videotaped procedure.

During 5 min of free play with their children, mothers spontaneously named any of 23 common toys (e.g., a brown furry plastic dog, a blue fish).[2] At the beginning of this free play, mothers were asked to play with their children using the toys. This served to acclimatize mothers and their children to being video-recorded and to capture naturalistic interactions during the next phase. The toys remained on the sheet within mothers' reach throughout the procedure.

Following free play, the main phase, a 5-min semi-structured play episode, began. Mothers were handed the target toys one at a time (Fig. 1) and asked to teach their infants, toddlers, or children the names for the two novel objects and actions. Mothers were not instructed on how they should name them. Mothers named all four referents, each for approximately 1 min 15 s (i.e., 75 s), speaking the language(s) they used at home with their children. Of the 24 mothers, 11 taught the two action names first and 13 taught the two object names first. During semi-structured play, mothers also named other referents on the scene (similar to Gogate et al., 2000), allowing direct comparison of naming in teaching (target) and non-teaching (non-target) contexts. During the play episode, mothers spoke one of the following languages: Malayalam ($n = 2$), Telugu ($n = 2$), Tamil ($n = 2$), Hindi/Urdu ($n = 3$), Marwadi ($n = 1$), Konkani ($n = 1$), Kannada ($n = 11$), or English ($n = 2$). The 11 monolingual mothers spoke only an Indian language. The bilingual mothers spoke predominantly an Indian language and some English ($n = 11$) or vice versa ($n = 2$).

Coding of play episodes: target and non-target words

Trained observers coded mothers' *target* naming of objects and actions (1482 naming occurrences or tokens) on time-coded videotapes (hours, minutes, seconds, and frames) using their best judgment into one of the following bimodal (auditory–visual) naming styles: naming synchronous with object motion (*s*), naming asynchronous with object motion (*a*), naming of a static object (*st*), or naming

[2] The 23 toy objects consisted of a brown dog, a multi-colored clown with curly hair, a yellow fish, a multi-colored lion on an ice cream cart that spun on a base with wheels, a plastic dial-up telephone, a yellow duck, a stuffed cloth caterpillar without legs, a stuffed pink rabbit, a green turtle sock puppet with moveable open mouth and black eyes, a stuffed blue shark, a black plastic wristwatch with an exposed dial and strap, a stuffed black killer whale, a plastic baby doll, a plastic white rocking horse, a plastic picture book, a stuffed pink dolphin, a wooden giraffe, a stuffed black and white penguin, a red car with moveable wheels, a pink plastic pig, three white plastic eggs, four red or blue rectangular or cylindrical wooden blocks, and a blue rectangular piece of foam.

of an object held by the infant (*iho*). They used the same criteria as in Gogate and colleagues (2000, 2006, 2013). A naming occurrence was coded as *synchronous* (*s*) if the mother uttered a target word while moving the object with only a small discrepancy (<150 ms) between word onset or offset and object motion, matching the bisensory temporal perception of prelexical infants (Lewkowicz, 1986). A naming occurrence was coded as *asynchronous* (*a*) if a word onset immediately preceded or followed onset of an object's motion, resulting in a greater discrepancy (>150 ms) between target word onset or offset and object motion onset or offset. The temporal proximity of auditory and visual elements made mothers' asynchronous naming distinguishable from naming of a static object. If a mother named an object and moved it within 500 to 700 ms of word onset, it was coded as asynchronous. If she moved it 700 ms after word onset, it was coded as *static naming* (*st*). The onsets and offsets for 5% ($n = 50$) of the coded data for these three categories were calculated after uploading them onto Final Cut Pro (Adobe). They met the same coding criteria as in prior research. If a mother named a target object or an action while the infant manipulated the object, it was coded as *infant held object* (*iho*). Mothers sometimes spoke isolated target words, and at other times embedded them in a sentence. Just 5% of the target words ($n = 50$) were embedded in an entire phrase or clause that co-occurred with an object motion. These *globally synchronous* utterances were not analyzed further because the motion was not synchronous with a spoken single noun or verb but rather an entire spoken phrase. In addition, 30 target word tokens (2%) were not coded because mothers named them outside of the camera's view. No cases of naming without a referent were observed.

For each mother, we calculated the number of total target word tokens and mean frequency of each bimodal naming style (*s, a, st,* and *iho*). In addition, to compare across naming styles, we calculated a proportion of target word tokens for each naming style. These were derived by dividing a mother's target word tokens of each bimodal naming style by her total number of target word tokens summed across all naming (*s, a, st, iho, globally synchronous,* and *uncoded*).

Coders who were proficient in the language spoken by each mother identified her use of other words (they were not asked to teach) or non-target words that referred to concrete objects (e.g., teddy bear) or actions (e.g., Indian language equivalents of jumping or clapping), transcribed them using broad phonemic transcription, and coded them for bimodal and trimodal naming, identical to the target words. Mothers spoke non-target words often embedded in a sentence and rarely in isolation. Of the 2411 non-target word tokens, 8% ($n = 199$) were not coded because the mothers named them outside of the camera's view. Of the non-target words, 5% ($n = 155$) were globally synchronous or embedded in a phrase or clause that was synchronized with an object's motion. The total number, mean frequencies, and proportions of total non-target (other) words were calculated, identical to the target words. The proportions were derived by dividing a mother's number of non-target word tokens in each naming style by her total number of non-target word tokens summed across all naming types.

Interrater reliability

The mean intraclass correlation coefficient of two coders' proportions of total target word naming classified into the six bimodal naming styles (*s, a, st, iho, globally synchronous,* and *uncoded*) and averaged across 8 mothers (33%, at least 2 dyads randomly selected from each age) was .94 ($SD = .09$), and that for total non-target word naming averaged across 5 mothers (21%) was .93 ($SD = .04$). The intraclass correlation coefficient between two coders' proportions of *auditory–visual–tactile* (*avt*) synchrony for target words averaged across the 8 mothers was .94, and that for non-target words averaged across the 5 mothers was .99.

Results

Maternal bimodal (auditory–visual) naming

In this section, first we report analyses of maternal naming of target and non-target referents (using nouns and verbs) taken together, and then we report analyses of maternal naming of objects separate from their naming of actions.

Maternal naming of target versus non-target referents and children's age

If synchrony highlights novel word–referent relations, then Indian mothers should synchronize target words more often than non-target words with a referent's motion and this should interact with children's level of lexical development. To test this hypothesis, we performed a repeated-measures analysis of variance (ANOVA, general linear model) of the proportions of target and non-target words (the dependent variable)[3] by bimodal naming (4) by word type (2) by children's age (3).

As predicted, the ANOVA revealed a significant interaction between word type (target or non-target) and bimodal naming, $F(3, 63) = 41.62$, $p < .0001$, $\eta^2 = .67$. Mothers used synchronous spoken words and object motion more often when naming target referents ($M = .61$, $SD = .26$) than non-target ones ($M = .37$, $SD = .24$) regardless of children's age (Scheffé's multiple comparison post hoc t test, $p < .05$ in this and all subsequent post hoc analyses). Like American mothers (Gogate et al., 2000), Indian mothers used synchrony more often when explicitly teaching novel word–referent relations. In contrast, they held objects static more often when naming non-target referents ($M = .35$, $SD = .16$) than target ones ($M = .17$, $SD = .13$), which did not differ from the proportions of synchronous naming (*s*, $M = .37$, $SD = .24$). Thus, as predicted, when mothers do not explicitly teach word–referent relations, their naming was not primarily characterized by synchronous verbal labels and gestures. Other naming types (*a* and *iho*, *p*s > .05) did not differ by target and non-target word type. Surprisingly, although predicted, no three-way interaction was found ($p > .10$), showing no relation between maternal bimodal naming, word type, and children's age or lexical development (Table 1). Finally, the ANOVA revealed a main effect of bimodal naming, $F(3, 63) = 42.13$, $p < .0001$, $\eta^2 = .67$, and a marginal effect ($p < .10$) of children's age, $F(2, 21) = 3.09$, $p = .07$, but not word type ($p > .10$) (Table 1). Mothers used synchrony ($M = .49$, $SD = .04$) significantly more often than other naming styles (*a, st,* or *iho*) regardless of word type and children's age.

Furthermore, we predicted that if Indian mothers tailor their teaching of novel word–referent mappings to children's lexical mapping abilities, then (like American mothers) their target–referent naming should interact with children's age. A repeated-measures ANOVA of mothers' proportion of total target words by bimodal naming (4: *s, a, st,* or *iho*) by children's age (3) yielded a significant interaction between children's age and maternal bimodal naming, $F(6, 63) = 6.34$, $p = .001$, $\eta^2 = .38$. As predicted, mothers of prelexical infants used synchrony ($M = .81$, $SD = .09$) more often than mothers of advanced lexical children ($M = .37$, $SD = .21$) (Table 1). Although mothers of early lexical toddlers also used synchrony more often ($M = .65$, $SD = .26$) (Table 1), their mean proportion of synchronous naming did not differ from the means of mothers of the younger or older group. In contrast, mothers of advanced lexical children named referents while holding an object static ($M = .26$, $SD = .15$) more often than mothers of the younger groups (prelexical: $M = .12$, $SD = .09$; early lexical: $M = .14$, $SD = .12$). In contrast, as predicted, Indian mothers did not tailor their non-target naming to their children's level of lexical development. A repeated-measures ANOVA of the proportions of total other words by bimodal naming (4) by children's age (3) yielded no interaction between these factors, $F(6, 63) = 2.12$, $p = .11$, $\eta^2 = .17$ (Table 1).

Mothers' bimodal naming of objects versus actions

Preliminary analyses revealed that Indian mothers used verb tokens (2133) slightly more often than nouns (1760) across target and non-target words. They named target objects about as often as non-target objects (847 vs. 903 tokens), but they named non-target actions more often than target actions (1508 vs. 625 tokens), illustrating verb dominance in Indian mothers' language.

We assessed whether mothers tailor their naming to their children's lexical development when they explicitly teach each lexical category—nouns or verbs. We expected Indian mothers to adapt to their children's greater difficulty in learning fleeting verb–action relations in a verb-dominant language by using synchrony to highlight verb–action relations much later in development but not noun–object relations relative to American mothers (Gogate et al., 2000). Each mother's total number of nouns or verbs in each bimodal naming style (*s, a, st, iho, globally synchronous,* or *uncoded*) was divided by her total nouns or verbs across naming styles for target and non-target words to obtain sets of proportions.

[3] Each proportion was calculated using multiple observations per mother (see Tables 1–3). The repeated-measures analyses eliminated within-participant variation, and a small sample size yielded robust effect sizes. The sum of the analyzed proportions does not equal 1 because the uncoded and globally synchronous tokens were excluded from the ANOVAs.

Table 1
Numbers (mean frequencies) and mean proportions (standard deviations) of mothers' bimodal naming by word type and children's lexical development.

	Bimodal naming			
	Moving-synchronous (s)	Moving-asynchronous (*a*)	Naming of a still object (*st*)	Naming when infants held an object (*iho*)
Prelexical (5–8 months, *n* = 8)				
Target words				
Raw total (mean frequency)	398 (48.63)	18 (2.25)	60 (7.50)	16 (2.00)
Mean proportion (SD)	.81 (.09)	.05 (.05)	.12 (.09)[a]	.02 (.04)[a]
Non-target words				
Raw total (mean frequency)	173 (21.63)	12 (1.50)	189 (23.63)	35 (4.38)
Mean proportion (SD)	.47 (.22)	.03 (.04)	.36 (.15)	.03 (.07)
Early lexical (9–17 months, *n* = 8)				
Target words				
Raw total (mean frequency)	349 (33.67)	20 (2.17)	59 (7.33)	65 (5.00)
Mean proportion (SD)	.65 (.26)	.04 (.06)	.14 (.12)[a]	.12 (.14)[b]
Non-target words				
Raw total (mean frequency)	221 (21.33)	41 (3.12)	198 (22.50)	104 (9.00)
Mean proportion (SD)	.40 (.25)	.07 (.04)	.28 (.14)	.13 (.14)
Advanced lexical (20–43 months, *n* = 8)				
Target words				
Raw total (mean frequency)	200 (25.00)	30 (3.75)	130 (16.25)	57 (7.13)
Mean proportion (SD)	.37 (.21)[b]	.05 (.05)	.26 (.15)[b]	.15 (.17)[b]
Non-target words				
Raw total (mean frequency)	235 (29.4)	96 (12.00)	564 (70.50)	189 (23.60)
Mean proportion (SD)	.23 (.19)	.10 (.09)	.40 (.19)	.13 (.09)
Grand total				
Target words				
1482[c]	947 (39.46)	68 (2.83)	249 (10.42)	138 (5.75)
	.61 (.27)[a]	.05 (.05)	.17 (.13)[a]	.10 (.13)
Non-target words				
2411[d]	629 (26.21)	149 (6.21)	951 (39.63)	328 (13.67)
	.36 (.24)[b]	.07 (.07)	.35 (.16)[b]	.09 (.11)

[a,b] Scheffé's multiple comparisons two-tailed $p < .05$ across age groups within bimodal naming type.
[c] Of the 1482 target word tokens, 50 (.05) were globally synchronous and 30 (.02) were not codable.
[d] Of the 2411 non-target word tokens, 155 (.03) were globally synchronous and 199 (.08) were not codable.

Maternal naming of target versus non-target objects. We assessed whether Indian mothers tailor their bimodal naming of novel objects to their children's level of lexical development. As predicted, a repeated-measures ANOVA of mothers' proportion of object names by bimodal naming (4) by noun type (2: target or non-target) by children's age (3) yielded a significant three-way interaction between children's age (3), maternal noun type (2), and bimodal naming (4), $F(6, 63) = 2.30$, $p = .045$. Mothers of prelexical infants ($M = .82$, $SD = .16$) and early lexical toddlers ($M = .60$, $SD = .27$) used target words in synchrony with an object's motion more often than mothers of lexically advanced children ($M = .38$, $SD = .05$) (Table 2). In contrast, mothers of lexically advanced children ($M = .41$, $SD = .09$) and early lexical toddlers ($M = .32$, $SD = .09$) used target nouns while holding an object static more often than mothers of prelexical infants ($M = .13$, $SD = .05$). The analyses did not yield significant differences by children's age in mothers' naming of non-target objects. Like American mothers (Gogate et al., 2000), Indian mothers tailor their novel target object naming to children's level of lexical development.

The ANOVA also yielded an interaction between bimodal naming and noun type, $F(6, 63) = 11.04$, $p = .001$, $\eta^2 = .35$. Mothers used target nouns more often in synchrony with object motion ($M = .56$, $SD = .31$) than non-target nouns ($M = .24$, $SD = .29$) regardless of children's age. In addition, the ANOVA yielded an interaction between maternal bimodal naming and children's age, $F(6, 63) = 4.02$, $p = .02$, $\eta^2 = .31$. Mothers of prelexical infants, but not mothers of early lexical toddlers, named objects in synchrony with object motion ($M = .54$, $SD = .08$) more often than mothers of lexically advanced children

Table 2
Numbers (mean frequencies) and mean proportions (standard deviations) of mothers' bimodal object naming by word type and children's lexical development.

	Bimodal naming			
	Moving-synchronous naming (*s*)	Moving-asynchronous naming (*a*)	Naming of a still object (*st*)	Naming when infants held an object (*iho*)
Prelexical (5–8 months, *n* = 8)				
Target nouns				
Raw total (mean frequency)	241 (30.13)	7 (.88)	32 (4.00)	4 (.50)
Mean proportion (SD)	.82 (.16)[a]	.04 (.05)	.13 (.15)[a]	.01 (.04)[a]
Non-target nouns				
Raw total (mean frequency)	39 (4.88)	2 (.25)	66 (8.25)	10 (1.25)
Mean proportion (SD)	.27 (.35)	.004 (.01)	.17 (.24)	.02 (.06)
Early lexical (9–17 months, *n* = 8)				
Target nouns				
Raw total (mean frequency)	215 (26.88)	14 (1.75)	50 (6.25)	50 (6.25)
Mean proportion (SD)	.60 (.27)	.05 (.08)	.17 (.15)[a]	.13 (.16)[b]
Non-target nouns				
Raw total (mean frequency)	12 (1.50)	4 (.50)	39 (4.88)	19 (2.37)
Mean proportion (SD)	.23 (.33)	.13 (.35)	.32 (.29)	.10 (.14)
Advanced lexical (20–43 months, *n* = 8)				
Target nouns				
Raw total (mean frequency)	61 (7.63)	17 (2.13)	93 (11.62)	35 (4.37)
Mean proportion (SD)	.26 (.20)[b]	.05 (.06)	.38 (.14)[b]	.20 (.22)[b]
Non-target nouns				
Raw total (mean frequency)	111 (13.87)	48 (6.00)	307 (38.37)	99 (12.37)
Mean proportion (SD)	.22 (.19)	.08 (.09)	.41 (.17)	.14 (.11)
Grand total				
Target nouns				
857[c]	517 (21.54)	38 (1.58)	175 (7.29)	89 (3.71)
	.56 (.31)[a]	.04 (.06)	.23 (.18)[a]	.11 (.17)
Non-target nouns				
903[d]	162 (6.75)	54 (2.25)	412 (17.17)	128 (5.33)
	.24 (.29)[b]	.07 (.21)	.30 (.25)[b]	.09 (.12)

[a,b] Scheffé's multiple comparisons two-tailed $p < .05$ across age groups within bimodal naming type.
[c] Of the 847 target noun tokens, 17 (.02) were globally synchronous and 21 (.04) were not codable.
[d] Of the 903 non-target noun tokens, 72 (.08) were globally synchronous and 75 (.09) were not codable.

($M = .24$, $SD = .08$) regardless of noun type (target or non-target). In contrast, mothers of lexically advanced children named static objects more often ($M = .40$, $SD = .05$) than mothers of prelexical infants ($M = .15$, $SD = .05$).

Finally, the ANOVA yielded main effects of bimodal naming, $F(3, 63) = 20.29$, $p < .0001$, $\eta^2 = .49$, and noun type, $F(1, 63) = 13.04$, $p = .002$, $\eta^2 = .38$, but not children's age, $F(2, 21) = 1.99$, $p = .16$. Post hoc t tests of the noun type effect revealed that mothers used a greater proportion of target nouns ($M = .24$, $SD = .006$) than non-target nouns ($M = .18$, $SD = .015$) regardless of bimodal naming or children's age (Table 2). Post hoc t tests of the bimodal naming effect revealed that mothers used nouns in synchrony with object motion ($M = .40$, $SD = .04$) more often than other naming styles regardless of noun type or children's age (Table 2).

Maternal naming of target versus non-target actions. We assessed whether Indian mothers tailor their explicit teaching of action names to their children's lexical development. A repeated-measures ANOVA of mothers' proportion of action names by bimodal naming (4) by verb type (2: target or non-target) by children's age (3) was performed. Surprisingly, we found no three-way interaction between naming type, verb type, and children's age ($p > .10$), suggesting no difference in mothers' tailoring of their bimodal target versus non-target action naming to children's level of lexical development (Table 3). However, the ANOVA yielded a significant two-way interaction between bimodal naming (4) and verb

Table 3
Numbers (mean frequencies) and mean proportions (standard deviations) of mothers' bimodal action naming by word type and children's lexical development.

	Bimodal naming			
	Moving-synchronous naming (*s*)	Moving-asynchronous naming (*a*)	Naming of a still object (*st*)	Naming when infants held an object (*iho*)
Prelexical (5–8 months, *n* = 8)				
Target verbs				
Raw total (mean frequency)	157 (19.63)	11 (1.37)	28 (3.50)	12 (1.50)
Mean proportion (SD)	.80 (.22)	.05 (.05)	.08 (.09)	.05 (.13)
Non-target verbs				
Raw total (mean frequency)	134 (16.75)	10 (1.25)	125 (15.63)	23 (2.88)
Mean proportion (SD)	.48 (.22)	.04 (.05)	.36 (.14)	.03 (.08)
Early lexical (9–17 months, *n* = 8)				
Target verbs				
Raw total (mean frequency)	134 (16.75)	6 (.75)	9 (1.13)	15 (1.88)
Mean proportion (SD)	.77 (.27)	.04 (.07)	.06 (.05)	.11 (.14)
Non-target verbs				
Raw total (mean frequency)	212 (26.50)	37 (4.62)	158 (19.75)	84 (10.50)
Mean proportion (SD)	.42 (.25)	.07 (.03)	.27 (.15)	.13 (.14)
Advanced lexical (20–43 months, *n* = 8)				
Target verbs				
Raw total (mean frequency)	139 (17.38)	13 (1.63)	37 (4.63)	22 (2.75)
Mean proportion (SD)	.43 (.30)	.05 (.06)	.14 (.12)	.12 (.18)
Non-target verbs				
Raw total (mean frequency)	124 (15.50)	48 (6.00)	257 (32.13)	90 (11.25)
Mean proportion (SD)	.23 (.20)	.12 (.12)	.38 (.20)	.11 (.09)
Grand total				
Target verbs				
625[c]	430 (17.92)	30 (1.25)	74 (3.08)	49 (2.04)
	.67 (.30)[a]	.05 (.06)	.09 (.09)[a]	.10 (.15)
Non-target verbs				
1508[d]	470 (19.58)	95 (3.96)	540 (22.50)	197 (8.21)
	.37 (.23)[b]	.08 (.08)	.34 (.17)[b]	.09 (.11)

[a,b] Scheffé's multiple comparison two-tailed $p < .05$ across age groups within bimodal naming types.
[c] Of the 625 target verb tokens, 33 (.05) were globally synchronous and 9 (.01) were not codable.
[d] Of the 1508 non-target verb tokens, 83 (.04) were globally synchronous and 123 (.08) were not codable.

type (2: target or non-target), $F(3, 63) = 34.60$, $p < .0001$, $\eta^2 = .62$. Mothers tailored their novel action naming regardless of their children's level of lexical development. They used novel target verbs in synchrony with actions ($M = .67$, $SD = .31$) more often than non-target verbs ($M = .38$, $SD = .23$) and used non-target verbs in the presence of a static object ($M = .34$, $SD = .16$) more often than target verbs ($M = .09$, $SD = .09$) (Table 3). Also as predicted, the ANOVA yielded an interaction between maternal bimodal naming and children's age, $F(6, 63) = 3.39$, $p = .006$, $\eta^2 = .24$. Mothers of prelexical infants named actions in synchrony with an object's motion ($M = .64$, $SD = .07$) more often than mothers of lexically advanced children ($M = .26$, $SD = .04$) regardless of verb type.

Finally, the ANOVA yielded significant main effects of bimodal naming, $F(3, 63) = 45.20$, $p < .0001$, $\eta^2 = .68$, and children's age, $F(2, 21) = 4.22$, $p = .03$, $\eta^2 = .29$, but not verb type ($p > .10$). Mothers named actions, like objects, in synchrony with object motion ($M = .52$, $SD = .04$) more often than other bimodal naming styles regardless of verb type or children's age. Mothers of lexically advanced children used verbs less often ($M = .20$, $SD = .01$) than mothers of prelexical infants ($M = .24$, $SD = .01$) regardless of verb or bimodal naming type, perhaps an artifact of verb dominance.

Multimodal motherese in monolingual and bilingual mothers. We assessed the hypothesis that monolingual Indian mothers ($n = 11$) would use multimodal motherese to highlight verb–action relations

more often than noun–object relations relative to bilingual mothers (n = 13), who spoke an Indian language and English. A repeated-measures ANOVA of mothers' proportion of synchronous naming by lexical category (2: noun or verb) by word type (2: target or non-target) by language status (2: monolingual or bilingual) revealed a main effect of lexical category, $F(1, 22) = 8.56$, $p = .008$, $\eta^2 = .28$, word type, $F(1, 22) = 40.93$, $p < .0001$, $\eta^2 = .65$, and language status, $F(1, 22) = 16.77$, $p < .0001$, $\eta^2 = .43$, and a marginal interaction ($p < .10$) between word type and language status, $F(1, 22) = 3.11$, $p = .09$, $\eta^2 = .12$, but no predicted three-way interaction between them ($p > .10$). Monolingual mothers (adjusted $M = .61$, $SD = .12$) used multimodal motherese more often than bilingual mothers (adjusted $M = .33$, $SD = .12$) regardless of word type or lexical category. All mothers used it to highlight verb–action relations (adjusted $M = .53$, $SD = .08$) more often than noun–object relations (adjusted $M = .41$, $SD = .08$) regardless of word type, illustrating mothers' use of a strategy for teaching lexical categories that are still developing.

Maternal trimodal naming (auditory–visual–tactile synchrony)

Of mothers' target word tokens, 14% (227/1482) were synchronous with their moving an object and touching their infants with it, with trimodally synchronous target nouns ($M = .09$, $SD = .13$) occurring slightly more often than target verbs ($M = .05$, $SD = .07$). In contrast, for the non-target word tokens, only 5% (105/2411) were trimodally synchronous, with trimodally synchronous non-target verbs ($M = .04$, $SD = .08$) occurring more often than non-target nouns ($M = .01$, $SD = .03$). Each mother's trimodally synchronous target or non-target word tokens were divided by her total number of target or non-target word tokens, respectively, to obtain an *avt* (auditory–visual–tactile synchrony) proportion for each word type.

We assessed the hypothesis that Indian mothers should integrate auditory–visual–tactile information more often when using target words than non-target words if synchrony highlights novel word–referent relations. A repeated-measures ANOVA of the *avt* proportions by word type (2) by children's age (3) yielded a main effect of word type, $F(1, 21) = 11.34$, $p = .003$, $\eta^2 = .35$, but not children's age and yielded no interaction between them ($ps > .10$). As predicted, Indian mothers used trimodal synchrony with target words more often than non-target words (Fig. 2).

Discussion

The current findings from Indian mothers provide cross-cultural evidence for multimodal motherese that promotes infant word learning. Mothers abundantly used verbal labels simultaneously with gestures to show novel objects or to demonstrate novel actions in teaching contexts. Multimodal

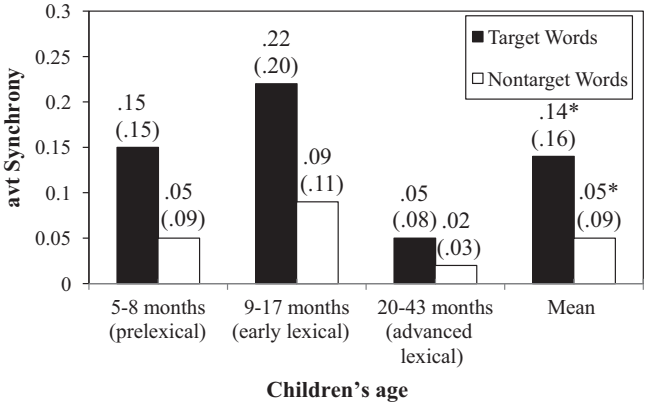

Fig. 2. Mothers' mean proportions (and standard deviations) of target and non-target words spoken in synchrony with object motion and touch (*avt*) by children's age (lexical development).

motherese also occurs naturally when mothers name novel objects to their infants in non-teaching contexts (Gogate et al., 2013). Mothers use synchrony to transfer knowledge—to foreground word–referent relations and reduce referential ambiguity for their word learning novice. Moving an object in synchrony with the word scaffolds attention to the object when it is being named, promoting attention to the object and its label. Infants use their mothers' synchrony to unify names with correct referents (Gogate et al., 2006). Caregivers' scaffolding of word mapping for infants, therefore, is instrumental in initiating infants into the multisensory world of communication.

Cross-cultural similarities

The current findings from Indian mothers' naming parallel some prior findings of Gogate and colleagues (2000) from Caucasian and Hispanic American mothers in the United States. Indian mothers spontaneously used synchrony between naming and showing an object or action to their children more often when they named target referents (using words they were asked to teach, 56%) than non-target ones (using other words, 37%). Similarly, mothers used trimodally (auditory–visual–tactile) synchronous naming more often for target referents (14%) than for non-target ones (5%). These results suggest that Indian mothers, similar to American mothers (in Gogate et al., 2000), highlight target (novel) word–referent relations more often than non-target ones by synchronizing their spoken words and object motions and sometimes touching their infants with the object.

This difference in mothers' naming of target versus non-target words was particularly salient in mothers of prelexical infants (5–8 months). Similar to American mothers, their target–referent naming to prelexical infants was primarily characterized by synchronous verbal labels and gestures (71%). In contrast, their non-target referent naming was characterized by far less synchronous verbal labels and gestures (48%) and greater naming in the presence of static objects (36%). Based on these findings, our main hypothesis that multimodal motherese forms a basis for preverbal infants' learning of novel word–referent relations across Western and non-Western cultures is supported. American and Indian mothers use multimodal motherese extensively to teach novel words to prelexical infants who are beginning to connect words and referents and to benefit from maternal scaffolding.

In further support of our hypotheses, the results suggest that, like American mothers, Indian mothers tailor their naming of novel referents to their children's lexical mapping development within a dynamic mother–infant communicative system. Indian mothers' novel referent naming to prelexical infants (5–8 months), but not to lexically advanced children (20–43 months), included a high level (81%) of synchrony between verbal labels and gestures. The decline in mothers' synchrony use during novel referent naming to lexically advanced children illustrates how mothers adapt their naming to their children's level of lexical development. Complementing this decline, mothers named novel referents more often in the presence of static objects or when children held an object. In contrast, when mothers named non-target referents, no difference was seen in maternal naming by children's age (Table 1).

How might synchrony facilitate word mapping in prelexical infants more than in lexically advanced children and initiate them into the multisensory world of communication? We provide a bidirectional mechanistic explanation that involves the organism and its sociolinguistic environment—the ongoing interaction between infants' perception and maternal scaffolding (Gogate & Hollich, 2010, 2013; Sullivan & Horowitz, 1983; Yu, Ballard, & Aslin, 2005). In general, caregivers coordinate their use of higher pitch exaggerated intonation contours, elongated speech, and longer pauses between utterances (Cooper, Abraham, Berman, & Statska, 1997; Fernald & Simon, 1984; Kitamura & Burnham, 2003) with simultaneous visual mouth movements (Bahrick & Pickens, 1988; Dodd, 1979; Legerstee, 1990; Meltzoff & Kuhl, 1994), more animated head movements and facial expressions (Smith & Strader, 2014; Walker-Andrews, 1997), and gestures using hands and body (Brand, Baldwin, & Ashburn, 2002; Brand & Tapscott, 2007). This coordinated information is *amodal*, invariant, and redundant; the same information conveyed to one sense modality is conveyed to another in the form of a common temporal structure, tempo, rhythm, and spatial colocation (see review by Gogate & Hollich, 2010). The intersensory redundancy is highly salient, elicits enhanced neural responses (Hyde, Jones, Flom, & Porter, 2011), and promotes infant perception, learning, and memory (Bahrick, 2010; Bahrick & Lickliter, 2002, 2012; Hollich, Newman, & Jusczyk, 2005; Lewkowicz, 2000). Because young infants are adept at perceiving synchrony, a type of intersensory redundancy, in speech and

non-speech events and synchrony unites auditory–visual stimuli, by 6 to 8 months they unify otherwise arbitrarily related spoken words and objects using synchrony while interacting with their mothers (e.g., Gogate et al., 2006; for older infants, see also Jesse & Johnson, 2012; Rader & Zukow-Goldring, 2010). Caregivers promote this unification by using multimodal motherese (Gogate et al., 2000; Messer, 1978). The current study is the first evidence for Asian Indian mothers' tailoring of multimodal motherese to their children's level of lexical mapping development.

Cross-cultural variations

A comparison with the findings from Gogate and colleagues (2000) suggests an important cross-cultural difference. In the prior study, American mothers' naming yielded a significant three-way interaction between bimodal naming (synchronous or asynchronous), word type (target or non-target), and children's age/lexical development when nouns and verbs were considered separately or taken together. It suggested that mothers tailored their target, but not their non-target, object and action naming to their children's level of lexical development. In contrast, in the current Indian sample, we found a three-way interaction only for nouns, but not verbs, or for both lexical categories taken together. We speculate that three factors contributed to the null interactions, with the third likely counteracting the first two.

Early in development, due to characteristics of the language, word frequency, and cultural practices, Indian children encountered a great number of verbs and their fleeting referents early on, making verb–referent mapping more challenging. Mothers likely adapted to this greater challenge by scaffolding their children's verb learning in two ways. First, they used synchrony more often during action naming (53%) than object naming (41%) in teaching and non-teaching contexts. Second, in teaching contexts, their synchrony use during novel action naming remained high for prelexical infants (80%) and early lexical toddlers (77%), declining only for lexically advanced children (43%). This adaptive use of multimodal motherese during action naming paralleled that of American mothers (Gogate et al., 2000), who spoke noun-dominant English or Spanish.

Counteracting these two factors, Indian mothers used synchrony abundantly to scaffold target noun learning much later in development to prelexical infants (82%) and early lexical toddlers (60%). Synchrony declined sharply only in mothers of lexically advanced children (26%). Owing to noun non-dominance in Indian languages, Indian children encounter fewer object names (e.g., Sethuraman & Smith, 2010) and might also benefit from prolonged scaffolding of noun learning. This prolonged scaffolding of nouns likely attenuated the three-way interaction between bimodal naming, word type, and children's age. In contrast, American mothers' greater synchrony use during target object naming to prelexical infants (71%), but sharp declines to early lexical toddlers (43%) and lexically advanced children (34%), likely strengthened the three-way interaction in Gogate and colleagues (2000). Given this cross-cultural difference in multimodal motherese, whether infants who learn verb-dominant versus noun-dominant languages (or both) will display different lexical development trajectories remains an open question.

Within-culture variations

The current study revealed within-culture scaffolding differences between monolingual mothers who spoke a verb-dominant Indian language and bilingual mothers who also spoke noun-dominant English. Monolingual mothers named objects and actions in synchrony with an object's motion far more often than bilingual mothers in teaching and non-teaching contexts. Thus, mothers tailor their use of multimodal motherese to the language-specific lexical dominance hierarchy and the degree of difficulty a lexical category might pose to their children, evidence for a dynamic and interactive mother–infant communicative system.

Implications and main conclusions

These findings from maternal naming, along with those from studies of infants' learning in the presence of synchrony (Gogate, 2010; Gogate et al., 2006), raise an interesting developmental question

about maternal naming and infants' learning and memory for word mappings. Do mothers tailor their naming to infants' developing ability to hold novel words and referents long enough in memory to pair them and later recognize the names for the referents when mothers use them? Whereas synchrony facilitates preverbal infants' mapping and short- and long-term memory for syllable (word)–object relations (Gogate, 2010; Gogate & Bahrick, 2001; Gogate et al., 2006), toddlers rely on it far less (Baldwin et al., 1996; cf. Jesse & Johnson, 2012). Early on, infants are unable to hold in memory a heard novel word and a visually perceived novel referent unless both word and referent are physically constrained to the "here and now" and unified by common temporal (e.g., Rader & Zukow-Goldring, 2010) and spatial (Samuelson, Smith, Perry, & Spencer, 2011) properties. As the ability to hold novel words and referents in memory develops, it frees toddlers from memory constraints, no longer requiring caregivers to constrain words and referents temporally or spatially to the here and now (Adamson & Bakeman, 2006). Thus, toddlers' reliance on invariant properties such as synchrony declines and comprehension of displaced word–referent relations emerges during the second year (e.g., "Where's the ball?" when it is in the next room). These findings suggest that the abundance of multimodal motherese to preverbal infants and infants' reliance on it early on are closely tied to initial memory constraints that gradually yield to more flexible memory for words, referents, and their relations. Consistent with this view, Indian mothers of advanced lexical children used synchrony less often when naming novel referents than mothers of prelexical infants.

In conclusion, the current quasi-experimental findings, taken along with those of Gogate and colleagues (2000), provide parallel evidence across Indian and American mothers for multimodal motherese, the synchronizing of gesture and spoken words, and tailoring of naming style to children's level of lexical development when explicitly teaching names for novel objects and actions. The greater use of multimodal motherese for prelexical infants who benefit most from it, but not for advanced lexical children, further substantiates a dynamic mother–infant communicative system that promotes word learning. In addition, the findings underscore an important cross-cultural difference: Indian mothers abundantly used multimodal motherese well beyond the prelexical phase when teaching object names, whereas its use declined sharply in American mothers (in Gogate et al., 2000). Finally, the current findings highlight a within-culture variation: Monolingual, verb-dominant Indian language-speaking mothers used multimodal motherese more often than bilingual mothers who also spoke English, a noun-dominant language. These findings emphasize the adaptations of a dynamic mother–infant communicative system that promotes infants' word learning in accord with language-specific lexical dominance hierarchies.

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