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Fathers' Infant-Directed Speech in a Small-Scale Society

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When speaking to infants, mothers often alter their speech compared to how they speak to adults, but findings for fathers are mixed. This study examined interactions ($N = 30$) between fathers and infants ($M_{age} \pm SD = 7.8 \pm 4.3$ months) in a small-scale society in Vanuatu and two urban societies in North America. Fundamental frequency (F_0) and speech rate were measured in infant-directed and adult-directed speech. When speaking to infants, fathers in both groups increased their F_0 range, yet only Vanuatu fathers increased their average F_0. Conversely, North American fathers slowed down their speech rate to infants, whereas Vanuatu fathers did not. Behavioral traits can vary across distant cultures while still potentially solving similar communicative problems.

When speaking to infants and young children, adults often modify their speech in a variety of ways. Researchers have long documented these child-directed communicative strategies, such as modifications of word structure, speech repetitions, and the use of particular changes in affective prosodic features (i.e., pitch, loudness, rhythm, and spectral features; Falk, 2004; Ferguson, 1977; Fernald, 1992; Snow & Ferguson, 1977). Why do we do this? Many scholars have suggested that infant-directed (ID) speech facilitates language learning (e.g., Nelson, Hirsh-Pasek, Jusczyk, & Cassidy, 1989), whereas others have noted its effectiveness in emotional communication between interactive partners (e.g., Fernald, 1992; Gergely & Watson, 1996). More recently, evidence suggests that infants form a social expectation based on the presence of ID speech during an interaction, using it as an ostensive communicative signal facilitating attention and subsequently altering behavior (Senju & Csibra, 2008). In any case, there is a wide consensus that ID speech is an important feature of the prelinguistic social life of infants.

Given that ID speech has been linked to some aspects of language learning (e.g., word segmentation), it may be useful for other aspects of language acquisition as well (Thiessen, Hill, & Saffran, 2005). We know that early language experience has long-lasting consequences on development and that early experience varies significantly both within and across cultural groups. For example, one ground breaking study by Hart and Risley (2003) examined variability in the ways in which parents and children interacted in 42 homes varying in socioeconomic backgrounds. They found striking differences in the patterns of family communication, including the number of words children hear daily and the kinds of messages the words conveyed. Children from low socioeconomic backgrounds (i.e., families on welfare) were compared to children from working class or professional families with high socioeconomic backgrounds. The children from low socioeconomic backgrounds heard significantly fewer words and less complex speech than children from working class or professional families. In fact, a linear projection of the gap in language exposure indicated that children from families on welfare heard approximately 30 million fewer words over the first 4 years of life compared to their peers from families of higher socioeconomic backgrounds. These differences were associated with significant discrepancies in children's knowledge, skills, and experiences, and continued to have lasting effects on children's performance later in life (Hart & Risley, 2003). Studies such as this highlight the impact of variability in experience and developmental outcomes; therefore, it may be particularly useful to develop a deeper understanding of one aspect of

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early language exposure: ID speech across various contexts.

The study of ID speech has been an interdisciplinary enterprise, and much of the research has been done across many different languages, although primarily from western, educated, industrialized, rich, and democratic (WEIRD) societies (Henrich, Heine, & Norenzayan, 2010). Research from WEIRD populations often does not generalize to other cultural groups, so analyses incorporating disparate societies are needed in all domains of social science (Henrich et al., 2010). In fact, this has been noted to be especially problematic in developmental science (Legare & Harris, 2016). In a recent review of comparative and cross-cultural developmental psychology, Nielsen and Haun (2016) reported significant differences in children's behavior across diverse societies and in a variety of important domains such as prosocial development, cooperation, and collaboration, early theory-of-mind understanding, and social learning. This analysis demonstrates why a cross-cultural approach to understanding human development is critical.

Furthermore, ethnographers and psychological anthropologists have documented significant variation in early caregiving behaviors and parental goals across the globe, suggesting that a Western perspective may be biased. In particular, some scholars have proposed that ID speech is particular to an urban, educated population where parenting practices and values emphasize language, education, pedagogy, and independence (Lancy, 2010, 2016; Odden & Rochat, 2004; Ratner & Pye, 1984). Additionally, ethnographies report that parenting goals in many rural, traditional societies often reflect an interdependent, pediatric focus with more attention on the physical health and well-being of the infant and less attention on the psychological development of the child (LeVine et al., 1994). This work also indicates that there may be very little face-to-face interaction with infants, and adults report not speaking to infants, claiming that infants are "without a mind" (LeVine et al., 1994). Recent work by Clegg and Legare (2016) showed interesting cultural differences in the degree to which children in a small-scale island society imitated instrumental actions with high fidelity compared to U.S. children. This research points to interesting potential differences in the way "learning from others" is socialized in the first few years of life. Such variability in caregiving and early infant experience suggests that parents may use different communicative strategies when interacting with infants. Interestingly, what little research that has been done on nonverbal features of ID speech in traditional societies suggests that many of the same acoustic features documented in western mothers' ID speech are present and detectable in small-scale societies as well (Bryant, Lienard & Barrett, 2012; Broesch & Bryant, 2015; Scelza, Bryant, & Cartmill, 2014). This suggests that despite ethnographic reports of significant variation in parenting and child care, some basic elements remain similar across disparate groups (Broesch, Rochat, Olah, Broesch, & Henrich, 2016).

Other cross-cultural investigations of caregivers and their infants found significant differences that vary along dimensions of interrelatedness and autonomy (Keller, Kärtner, Borke, Yovsi, & Kleis, 2005). Keller and colleagues studied early mother–infant interactions across cultures (Cameroonian Nso and German middle-class mothers) and found differences in their interactive style with Nso mothers engaging in a more proximal parenting style (e.g., high in body contact) and German mothers engaging in a more distal parenting style (e.g., high in eye contact and vocalizations). The authors found correlations between maternal parenting style at 3 months and infants' performance on a social-cognitive task, recognizing oneself in the mirror, at 18 months. Nso infants passed the test for self-awareness at a later age than German infants. This research suggests that the early parent–infant relationship reflects societal beliefs that, in turn, may affect the developmental pathway of the infant.

Furthermore, a handful of studies conducted in small-scale rural islands in the South Pacific have also reported significant differences in parent–child interactions, deviating from the Western model of childrearing practices (Broesch et al., 2016; Little, Carver, & Legare, 2016; Rochat et al., 2009). Broesch and co-authors (2016) documented similarities in basic levels of infant responsiveness but differences in the selective responding to emotional bids suggesting that as early as the 1st year of life there are cultural differences in parenting strategies for socializing emotion and nonverbal communicative behavior (see also Legare & Harris, 2016 for a review of different cultural strategies). Cultural differences have also been found in the ways parents engage in triadic interaction with their infant and an object. Little et al. (2016) examined caregiver–infant interactions in Vanuatu and the United States, and found significantly more physical triadic engagement in dyads from Vanuatu and more visual triadic engagement with dyads from the United States. Overall, these studies point to the possibility that the Western model of caregiving may be

specific to urban, North American populations and aspects of the early social environment need to be examined beyond this cultural context.

Studies of ID speech have mostly focused on mothers. This fact reflects a problematic assumption in developmental psychology: the primacy and monotropy of the mother–infant relationship. For instance, this assumption is embedded in *attachment theory*, one of the field's foundational concepts. Theorists are currently pushing for a more thorough understanding of development as it exists in many forms and relationships as revealed by ethnographic reports of diverse caregiving strategies across societies (Keller, 2013). Surprisingly, very little is known about paternal ID speech. We know that fathers play an important role in infants and children's lives, but little research has examined *how* fathers interact with their infants. Is it similar or different from mothers? If so, how and why? Our investigation seeks to better understand the role of fathers.

As mentioned earlier, a majority of the work on ID speech has focused on female caregivers, hence the common expression "motherese," even though paternal care of young children is reported worldwide. Because fathers in many societies across the globe often play a significant role in child development, it is important to understand the complexities of variation in father–infant interactions (Lamb, 2013). In the current study, we explored two basic acoustic features of paternal ID speech: fundamental frequency, which corresponds to perceived pitch, and speech rate. The goal was to determine how fathers across very different social ecologies—specifically an urban, industrial society and a rural, small-scale island society—modified their spontaneous speech directed toward their infant compared to speech directed toward an adult.

The role of fathers across cultures has received considerable attention over the past 40 years, including early reports of variation in parenting practices across diverse cultural contexts (Whiting & Whiting, 1975) and more recent examinations of small-scale societies such as agrarians (LeVine et al., 1994) and hunter-gatherers (Fouts, 2008; Hewlett, 1991). LeVine et al. (1994) proposed a parenting model of indulgent or pediatric care as a result of high infant mortality that he contrasted with urban–industrial societies where infant mortality is low and parents invest in few offspring. In societies with high infant mortality, he suggested that parents focus on or "indulge in" the survival and health of the infant rather than focus on the psychological development and well-being of the child.

Other research examining paternal practices across diverse societies has described significant differences in fathers' behaviors with their children in the first few years of a child's life. For example, Hewlett (1987) examined paternal involvement in Aka foragers in the Central African Republic of Congo in comparison to a neighboring group and reported significantly higher levels of intimacy between Aka fathers and their offspring. By his account, Aka fathers hold and nurture their offspring to a degree unseen in other societies (Hewlett, 1987). In a review of the existing data of fathers and child care across preindustrial societies, Hewlett (1991) reported studies suggesting that father involvement is greater when population density is low, as, for example, in island societies. This work illustrates one of the many reasons we might expect significant cultural variation in the ways caregivers—in this case fathers—talk to their babies. Our understanding of this work is that intimacy reflects, among other things, time spent with infants. Time spent may be related to how well one knows their communicative partner and therefore the extent to which one modifies their behavior to facilitate learning or comprehension. Although we do not test this directly, we expect that fathers who spend more time with infants recognize the benefits of the features of ID speech and modify their behavior to a greater degree. Nevertheless, we should expect a fair degree of universality as well.

One central theoretical reason we should expect at least some widely shared characteristics in ID speech across disparate cultures is because the acoustic features of the vocal signals are carrying out the communicative functions (Bryant & Barrett, 2007; Fernald, 1992; Owren & Rendall, 2001). This form–function principle in the evolution of signaling has been developed to understand many kinds of mammalian communication systems, including vocalization patterns across many taxa (Morton, 1977). That is, the relationship between sound and meaning is shared across many species because we share mechanisms for producing and perceiving vocalizations. Fernald (1992) described how the forms of ID speech can help us understand its functions, which are likely developmentally timed and the product of an adaptive system. For example, global acoustic features such as raised and variable vocal pitch, or slowed speech rates, can help caregivers recruit an infant's attention (Werker & McLeod, 1989) and effectively communicate emotional intentions to an infant with limited perceptual abilities (Fernald, 1992). Converging evidence shows clearly that infants usually prefer this style

of speech over adult-directed (AD) speech (e.g., Pegg, Werker, & McLeod, 1992), suggesting a prepared learning system that takes ID speech as input. As a child begins learning language, certain aspects of ID speech might shift toward emphasizing linguistic information such as vowel categories (Kuhl et al., 1997) or syntactic properties of speech (Thiessen et al., 2005). This system is, however, also subject to the constraints of language and cultural evolution (Barrett, 2015), with a suite of factors driving adult–infant interaction patterns, meaning that important variation could exist not only in whether adults even talk to babies but what kinds of modifications they might produce. An important component of an infant's early environment is the communicative connections established with caregivers. Here, we focus on one aspect of that connection—the vocal channel. Voices are a rich source of information for young infants, with maternal identification occurring just after birth (Mehler, Bertoncini, Barrière, & Jassik-Gerschenfeld, 1978).

Psycholinguistic research comparing the acoustic properties of paternal and maternal ID speech is somewhat mixed and difficult to interpret. Most studies report that fathers modify their speech in some way when addressing their infants. For example, Papousek, Papousek, and Haekel (1987) examined vocal dialogs between German-speaking parents and their 3-month-old infants. They report striking similarities across a variety of speech measures. Fathers talked as much as mothers, modified their speech characteristics in similar ways such as increased overall pitch, slowed speaking rate and exaggerated intonation patterns. Fernald et al. (1989) examined ID speech across several languages, including two dialects of English, and found remarkable consistency in both mothers and fathers' pitch and duration modification, though they also report that fathers produced less pitch range than mothers and produced longer pause durations. Rondal (1980) also examined parent speech to children (1–3 years) across a variety of contexts and reports similarities in mothers' and fathers' speech to children. Jacobsen and colleagues (Jacobson, Boersma, Fields & Olson, K. 1983) also found consistent behavior between mothers and fathers in their ID speech properties and reported that men who were not parents produced these features no differently than men who were parents.

Other research has documented differences in the ways fathers and mothers adjusted their speech when addressing young children. One study looking at American parents' speech to infants indicated that fathers modified their vocal pitch similarly to mothers—both increasing their mean pitch and pitch variability when speaking to 2-year-old children. But unlike mothers, fathers did not alter their pitch to 5-year-olds any differently than speaking to another adult (Warren-Leubecker & Bohannon, 1984). Furthermore, Shute and Wheldall (1999) reported that British fathers increased their average pitch and pitch variability when conversing with their 1- to 3-year-old children, compared to conversing with an adult, which is similar to what British mothers did in an earlier study (Shute & Wheldall, 1989). But when reading to their infants as opposed to conversing, mothers and fathers differed: Mothers modified the mean pitch and pitch variability in their speech when reading to children, whereas fathers only raised their pitch and did not increase their pitch variability. Interestingly, it was only in the reading condition that fathers slowed down their speech rate, taking longer to read passages, something mothers did not do. One interpretation of these findings is that the specific acoustic modifications may serve different functions, with an average increase in pitch and a change in speech rate possibly accomplishing different goals. For example, decreases in speech rate might facilitate language learning and comprehension by reducing infant listeners' cognitive processing load, whereas changes in vocal pitch might enrich affective communication and attunement. In general, the forms of the vocal signals will be intimately tied to the communicative goals that they fulfill.

The current work further examines the potential sensitivity of the acoustic properties of ID speech to cultural and social contexts. Other research has found support for the general notion that fathers play a unique role in infant learning and development. In fact, some have proposed that fathers play a special role in facilitating language learning in infants and toddlers by using more complex speech than mothers. Mothers modify the emotional properties of their speech and use simpler words and shorter sentences, whereas fathers use more complex speech and often do not modify the acoustic properties to the same extent as mothers. McLaughlin, White, McDevitt, and Raskin (1983) referred to this as the differential experience hypothesis and suggested that mothers are more attuned to the child's language abilities, whereas fathers put more linguistic demands on the child, using more complex speech to children. Others have referred to this as the bridge hypothesis, suggesting that fathers, or secondary caregivers, act as the bridge to the language of the outside world, providing a context for language learning (Gleason, 1975; Lamb, Pleck,

Charnov, & Levine, 1987; Barton & Tomasello, 1994; Tomasello, 2009). The idea is that fathers present children with communicative challenges, accommodating to them much less than the mother, and therefore stretch the boundaries of language communication. Other evidence in support of this idea comes from a longitudinal study of fathers' and mothers' speech to children (Pancsofar & Vernon-Feagans, 2010). Fathers' education and vocabulary to their child during a book reading task was predictive of children's language development even after controlling for a number of demographic and individual differences in children's characteristics. In another study, Rowe, Coker, and Pan (2004) examined mothers' and fathers' talk to toddlers in low-income families, and although mothers and fathers did not differ in the complexity of their speech to children, fathers produced more wh questions and clarification requests than mothers, resulting in more conversational challenges to the children. Taken together, these studies suggest that fathers and mothers may play different roles in the facilitation of early communication and language development.

Other research has examined the developmental impact of variability in fathers' speech to infants and young children, suggesting that rich paternal ID speech facilitates language learning (Kaplan, Sliter, & Burgess, 2007; Malin et al., 2012). Kaplan and colleagues explored the role of elevated depressive symptoms on fathers' ID speech and subsequent infant learning on an association task, with several interesting discoveries. Fathers with higher numbers of self-reported symptoms of depression also use ID speech differently (e.g., lower pitch) than fathers with fewer symptoms (Kaplan et al., 2007). Furthermore, paternal depressive symptoms had adverse effects on infant learning in a conditioned attention task. Infants of fathers who reported elevated depressive symptoms did not perform as well on an associative learning task. This suggests that paternal ID speech may play a role in early infant learning; although the learning task in this study is limited in scope, it could indicate that an environment rich in parental ID speech facilitates more rapid learning.

Furthermore, recent research examining ID speech, paternal depressive symptoms, income, education, and child language development revealed significant differences between fathers of low and high income and education levels and subsequent language development of their children (Malin et al., 2012). Fathers with higher levels of education had children who produced more utterances and had more diverse vocabularies than fathers with lower levels of education (Malin et al., 2012). Interestingly, fathers with more depressive symptoms had children with less grammatically complex language than fathers with fewer depressive symptoms. Furthermore, these findings were partially mediated by fathers' quantity and quality of language, suggesting that the kind and amount of linguistic input matters.

Although maternal ID speech is often quite similar across disparate cultural and linguistic boundaries (e.g., Broesch & Bryant, 2015), in the current study we examined the acoustic features of paternal ID speech in similar contexts across two disparate cultural groups (South Pacific and North American). To our knowledge, acoustic features of paternal ID speech have not been systematically examined outside of urban and primarily Western societies. In fact, very little is known about parent–infant communication in rural, non-Western, small-scale societies where caregiving practices are often deemed to be significantly different from those of an urban, large-scale society. Knowing more about the communicative style of fathers under varying conditions will provide a deeper understanding of fathers' role in infant development and the role of form and function in the production of ID speech.

Given that there are only a handful of studies investigating fathers and infants, and fewer still investigating fathers in a rural context, this study was largely exploratory. However, the implications are significant. If we find highly similar paternal acoustic modifications in these two very different societies, it would suggest that despite these drastically different societies, paternal ID speech may not be sensitive to contextual features of caregiving. Conversely, cultural differences in the ways fathers communicate with infants would suggest a rich and complex communicative system sensitive to context and would require further investigation to fully understand the factors underlying the variability as well as the impact of such variability on development. We suspect that such differences may reflect deep societal values about verbal and nonverbal communication, formal education, fatherhood, and the importance of relationships.

Method

Participants and Location

Thirty fathers were recorded producing both speech directed toward their infant (ID speech) and speech directed toward an adult (AD speech). These

paired samples included 12 fathers from a small-scale rural island society on Tanna Island in Vanuatu (ni-Vanuatu fathers) and 18 from two urban societies in North America: Vancouver, BC, Canada (n = 11), and Atlanta, GA, United States (n = 7). Twelve father–infant dyads from Tanna comprised all of the infants under 12 months in the three villages where we conducted our research on Tanna island during a visit in May 2013. Infant–father dyads from U.S. and Canada were tested in 2010 and 2013. The mean age of the fathers was 33.5 years (SD = 4.9), and there was no significant age difference between fathers from urban (M = 34.2, SD = 4.8) and small-scale (M = 32.2, SD = 4.9) societies, $t(23) = -0.913$, $p = .37$. During ID speech, fathers spoke to their own infants (M_{age} = 7.8 months, SD = 4.3). There was no significant difference in the age of infants between societies, $t(27) = 0.30$, $p = .76$. On average, fathers had 12.4 years (SD = 8.3) of formal education, and this was significantly different between small-scale (M = 4.1, SD = 3.84) and urban (M = 18.4, SD = 4.6) fathers, $t(24) = -8.25$, $p < .0001$.

Fathers were tested with their infants in three local laboratory settings—a quiet room in a house in the villages of Lounikawek community on Tanna Island, Vanuatu, and in a laboratory setting or a quiet room in a house in Vancouver, Canada and Atlanta, Georgia. None of the fathers tested were the primary caregivers of the infants, but all were self-declared as being involved in caregiving for their infant. Given the ecological conditions of families in Vanuatu, fathers are living in close quarters with infants, often sharing their sleeping space with the infant's mother and several other children. Not only are fathers expected to assist in basic ways with caregiving when present (e.g., holding the infant while the mother is busy with other domestic work such as meal preparation or care for other children), but also fathers and grandfathers appear to enjoy the presence of infants. Life in Vanuatu is more fluid and less based on a rigid schedule than typical North American cities. Emphasis is on subsistence living and less so on formal education or paid employment (both are rare). This is relevant to our research as fathers have more opportunities to spend time with their infants during infant waking hours. Entire families will often travel to the family garden together throughout the day, working together on child-care and subsistence activities. This contrasts with fathers tested in our urban North American sample who reported working full time, and spending their evening hours and weekends with infants.

Recording Procedure

Fathers were video-recorded interacting with their infants as part of a study examining fathering in small-scale societies. Prior to recording, informed consent was obtained by a native speaker in both locations. After consent was acquired, fathers and their infants were brought to the testing location and seated in a quiet corner of the room or outdoor area. Both the father and infant were seated on the floor, with the infant facing the father and within

Figure 1. Ni-Vanuatu father with his 7-month-old son.

arm's reach (see Figure 1). They were asked to play with their infant, with the goal of keeping the infant content and remaining in an enface position for approximately 10 min. The fathers were asked not to pick up the infant, but touching was allowed at the fathers' discretion. They were also told that if the infant cried, we would stop the camera, and if the infant fussed, they could signal to us to stop if they wanted. In both cases, we would only use the first few minutes of video, which would be sufficient for the study. Fathers were not explicitly instructed to talk to their infants (see Appendix S1 for verbal instructions). In order to obtain AD speech, fathers were asked general descriptive questions by a native speaker in both locations, at the beginning and end of the structured observation, such as the age and sex of the infant, as well as their general thoughts regarding the interaction.

Audio Extraction

The first 10 s of uninterrupted vocalizations directed toward the infant (and toward the adult for AD speech) was extracted for acoustic analysis. We defined a vocalization as any utterance or sound coming from the adult while engaging with the infant (or adult) but did not include sounds derived from only lip movements (e.g., speech raspberries). Obtaining the first 10 s of speech provided a consistent rule governing the choice of segments to analyze, and afforded the analysis of complete intonation contours. Vocalizations were extracted (*i*-movie software) and exported as uncompressed wav audio files (44.1 kHz, 16 bit, mono). Because the recording context was originally designed to capture episodes of free interaction between fathers and infants, some fathers had only brief episodes of AD speech. In cases where AD speech was less than 10 s in duration, we captured any instance of AD speech. Background and infant noise was not edited out at this stage, but if the infant vocalized consistently for more than 3 s, it was considered an interruption and the next 10-s instance was captured instead.

Acoustic Analysis

Extracted audio clips were analyzed using Praat version 5.2.21 (Boersma & Weenink, 2011). Fundamental frequency (F_0) is the acoustic correlate of perceived pitch and is defined acoustically as the lowest frequency in a periodic waveform (Titze, 2000). F_0 results from the vibration rate of the vocal folds, and variations in F_0 (perceptually manifesting as fluctuations in a speaker's pitch) are due to either subglottal air pressure changes or laryngeal muscle movements. Changes in pitch variation and pitch range can be due to innumerable factors connected with language, affect, and body state (for a comprehensive review, see Kreiman & Sidtis, 2011). We measured mean fundamental frequency (F_0), fundamental frequency variability (F_0 *SD*), and minimum and maximum F_0 values using an autocorrelation method. Octave errors and other analytical errors were removed by hand, or fixed through pitch setting adjustment. Default pitch settings suggested by Praat were used for men (100–500 Hz), but changes in these settings were done on a case-by-case basis after visual inspection of the F_0 values, never exceeding $\pm$ 10 Hz adjustment in the lower limit, and $\pm$ 50 Hz in the higher limit. F_0 standard deviation (F_0 *SD*) and F_0 range were used as measures of pitch variation. F_0 range was measured by subtracting the minimum F_0 from the maximum F_0 value for each speaker. To measure speech rate, we used a Praat script that detects syllable nuclei automatically (De Jong & Wempe, 2009) and generates syllables per second output. All files were low-pass filtered (4 kHz) to remove extraneous noise that could affect intensity and voicing measurements used in the script algorithm. Because of the spontaneous nature of the recordings, many sounds were present in addition to the fathers vocalizing and had to be edited out. All parts of the recording that included nontarget vocalizations (e.g., other people talking, crying babies, overlapping speech, animals, etc.) were removed prior to analysis. Recorded clips varied in the percentage of usable sound for acoustic analysis.

Urban speech samples (M = 4.61 s, SD = 3.04) were significantly longer than small-scale speech samples (M = 3.12 s, SD = 1.68), $F(1, 55) = 5.56$, $p = .022$, partial $\eta^2 = .09$. AD speech samples (M = 2.86 s, SD = 1.77) were shorter in length than ID speech samples (M = 5.12 s, SD = 2.92), $F(1, 55) = 11.59$, $p < .001$, partial $\eta^2 = .17$. Society type and speech type did not interact showing that the difference in length between AD and ID speech samples did not vary across cultures, $F(1, 55) = 1.81$, $p = .18$, partial $\eta^2 = .03$.

Results

Acoustic data were analyzed using generalized linear mixed models with the lmer procedure of the lme4 package (Bates, Maechler, Bolker, & Walker,

2015) in the statistical platform R (version 3.2.3; R Core Team, 2015). We created separate models for each dependent measure (semitone conversions of mean F_0, F_0 *SD*, F_0 range, and speech rate measured as syllables per second). Bartlett's test of homogeneity of variances indicated equal variances across speech types for all dependent measures (all *p*s > .05). Speech type (ID and AD) and society type (small-scale and urban) were entered as interacting fixed effects, and unique speaker (i.e., fathers) was entered as a random effect. Data were modeled using a Gaussian link function and without restricted maximum likelihood estimation. Probability values from the *t* distribution were generated with the parametric bootstrap and Kenward–Roger test (pbkertest) that approximates degrees of freedom (Halekoh & Højsgaard, 2014). Conditional R^2 ($R^2_{GLMM(c)}$) values describe the variance explained by both fixed and random factors, and marginal R^2 ($R^2_{GLMM(m)}$) values describe the variance explained by the fixed factors alone. In the current analyses, the two values represent variance explained both with and without the factor of unique fathers. These values were generated for each model using the R package "piecewiseSEM" (Lefcheck, 2015). This method of obtaining R^2 values for mixed models overcomes previous theoretical and practical limitations of so-called pseudo-R^2 estimates, and provides goodness-of-fit values not given by information criteria (Nakagawa & Schielzeth, 2013).

See Table 1 for random and fixed effects parameters for all four models. ID speech had higher mean F_0 than AD speech ($t = 3.50$, $p = .0005$; $R^2_{GLMM(c)} = .49$, $R^2_{GLMM(m)} = .17$), but an interaction between society type and speech type indicated the effect only occurred in rural fathers ($t = -2.42$, $p = .015$). ID speech did not differ from AD speech in F_0 variability (F_0 *SD*; $t = 1.49$, $p = .14$; $R^2_{GLMM(c)} = .05$, $R^2_{GLMM(m)} = .05$), and there was no interaction between society type and speech type ($t = -1.01$, $p = .31$). ID speech did differ from AD speech in F_0 range ($t = 2.38$, $p = .0004$; $R^2_{GLMM(c)} = .13$, $R^2_{GLMM(m)} = .13$), with no interaction between society type and speech type ($t = -0.74$, $p = .46$). Finally, ID speech was not different from AD speech in speech rate when collapsed across societies ($t = 0.40$, $p = .68$; $R^2_{GLMM(c)} = .30$, $R^2_{GLMM(m)} = .20$), but a significant interaction revealed that urban North American fathers spoke slower when using ID speech than when using AD speech, and small-scale ni-Vanuatu fathers did not show this pattern ($t = -2.89$, $p = .004$; see Figure 2 and Table 2).

Discussion

Fathers in both cultural groups modified the acoustic features of their speech in some way when interacting with infants, but the particular ways they did this differed across societies. Fathers from both

Table 1
Random and Fixed Effects Parameters for All Four Mixed Models

Model	Fixed factors	Random factors	Estimate	*SE*	*t*	Variance	*SD*	p.z
F_0	Intercept		84.506	1.006	84.04			.0000
	SpeechID		3.890	1.112	3.50			.0004
	Society1		3.645	1.298	2.81			.0050
	SpeechID × Society1		−3.485	1.436	−2.43			.0152
		Father				4.709	2.170	
F_0 *SD*	Intercept		2.9742	0.689	4.313			.0000
	SpeechID		1.4517	0.975	1.489			.1366
	Society1		1.1369	0.890	1.277			.2015
	SpeechID × Society1		−1.2817	1.258	−1.018			.3086
		Father				0.000	0.000	
F_0 Range	Intercept		11.25583	1.823	6.174			.0000
	SpeechID		6.12917	2.578	2.377			.0003
	Society1		0.02806	2.353	0.012			.9905
	SpeechID × Society1		−2.47194	3.328	−0.743			.4577
		Father				0.000	0.000	
Speech Rate	Intercept		2.8883	0.243	11.881			.0000
	SpeechID		0.1300	0.322	0.403			.6871
	Society1		0.6883	0.313	2.193			.0283
	SpeechID × Society1		−1.2072	0.416	−2.897			.0038
		Father				0.08405	0.289	

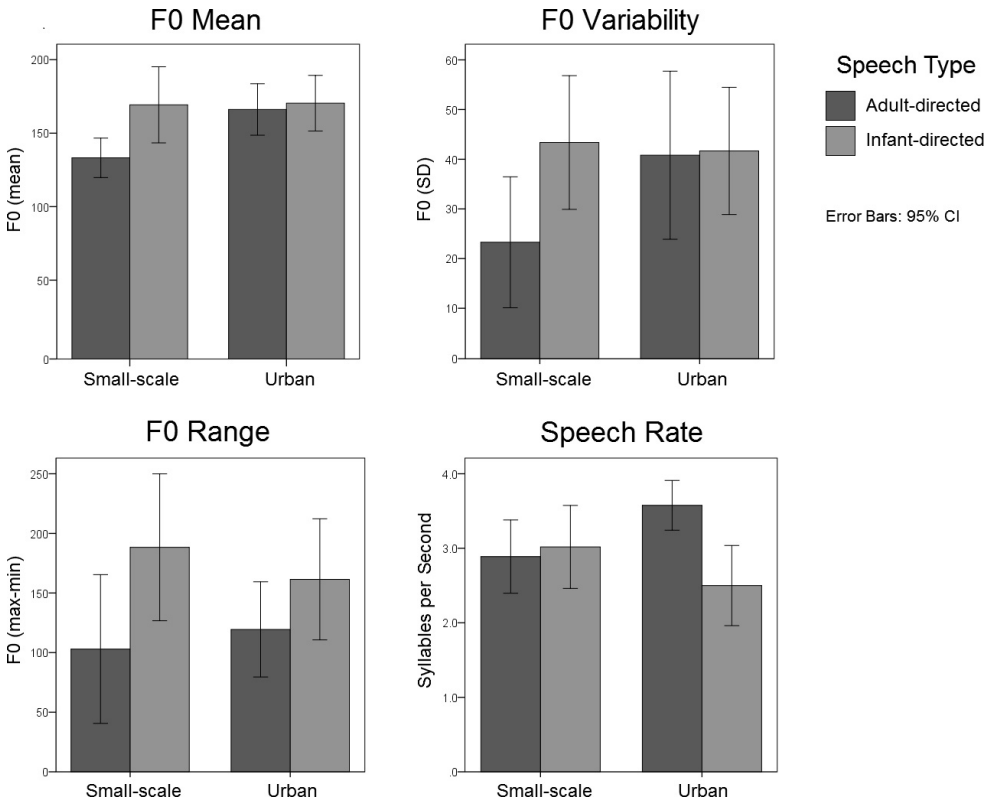

Figure 2. Mean fundamental frequency in Hertz (F_0), *SD* F_0, F_0 range, and syllables per second by society and speech type.

Table 2
Means and Standard Deviations of Three Pitch Measurements and Speech Rate in Infant-Directed and Adult-Directed Speech Across Small-Scale and Urban Groups (N = *30)*

	Small scale (n = 18)				Urban (n = 12)			
Speech type	Mean F_0	F_0 *SD*	F_0 range	Syl/s	Mean F_0	F_0 *SD*	F_0 range	Syl/s
Infant directed	169 (40.7)	43.4 (21.2)	188 (96.9)	3.02 (0.88)	170 (38.1)	42 (25.7)	162 (102.1)	2.50 (1.08)
Adult directed	133 (21.1)	23 (20.7)	102 (98.2)	2.88 (0.77)	166 (35.3)	41 (34.0)	130 (109.1)	3.57 (0.67)

All F_0 values in Hertz. Standard deviations in parentheses. Syl/s = syllables per second.

cultural groups increased their pitch range when speaking to infants compared to speaking with adults, but fathers in both groups did not significantly increase their pitch variability (F_0 *SD*). However, small-scale fathers modified their vocal pitch, using higher average pitch when speaking to infants compared to adults, whereas urban fathers did not. Furthermore, urban, North American fathers decreased the rate of their speech when addressing infants, whereas small-scale fathers in Tanna did not. These findings suggest systematic societal differences in how fathers communicate with young infants, indicating that they may use different strategies to solve the prelinguistic communicative challenge, and that caregiving practices depend on the social ecology in which the infants and parents live.

Although we do not yet have a measure of the amount and kind of direct care fathers provided to infants in either society, we assume that fathers typically differ across cultural groups in the kinds of experiences they have with their infants, which can lead to different communicative strategies. Here, we present two possibilities explaining our pattern of data. First, paternal behavior might reflect society-specific normative parenting goals with fathers in small-scale societies emphasizing relationships and emotional attunement, and fathers in urban

societies focusing on language learning and formal education. Although we cannot rule out this possibility, other results with maternal ID speech from these same societies are not consistent with this interpretation (Broesch & Bryant, 2015). In our earlier study, we found that mothers altered their speech in quite similar ways across these two societies. If normative parenting behavior was focused in such different ways, we should not see such similarity in vocal interaction patterns relevant to emotional signaling. However, it is possible that mothers and fathers emphasize different aspects of social development when interacting with infants, and this varies across cultures. A second possibility is that the amount or kind of vocal accommodation reflects paternal intimacy with infants. Paternal intimacy is impacted by a host of complex factors such as the social–political situation, fathers' supportive network, partner relationship quality, cultural norms surrounding parenting, among others (Lamb, 2013). Although in the current project we did not directly measure these demographic variables, we can speculate based on existing global data for each society, and future investigations might help elucidate the factors leading to our findings. Our results are consistent with one idea proposed by Hewlett (1991), who suggested that paternal involvement is higher in societies with lower population densities. The population density of Vanuatu (20.3 per km^2 in 2012 according to the U.N.) is substantially lower than that of urban Vancouver or Atlanta (5,249 and 3,199, respectively). The living conditions in Vanuatu might be more likely to predispose men to greater relative investment in their offspring because of the relatively lower competition for resources in a low population density context.

Furthermore, past research has found differences in speech rate between mothers and fathers during a book reading episode, but not during a conversation with their child, suggesting that slowing down one's speech when addressing a young child or infant may achieve a different function than altering one's pitch. Interestingly, in our research we found that Vanuatu fathers changed their average pitch, whereas North American fathers spoke more slowly when addressing infants (though also with increased pitch range). This potentially fits with the idea that speech rate reductions encourage language learning with a slow and careful articulation of words, whereas vocal pitch changes may reflect an emphasis on affective relationships. Exaggerated alterations in vocal pitch during ID speech are well-established emotional signals (Fernald, 1992), and are potentially better suited for emotional attachment than speech rate changes, although that is an empirical question. Both prosodic strategies are common across cultures in maternal ID speech, and can function to engage infants' attention better than AD vocal styles (Werker & McLeod, 1989).

The current study has some important limitations. First, our sample size was small. Our rural sample included every father with an infant at the time of our visit, but it is still rather difficult to generalize about larger cultural differences. Second, we do not have information about paternal investment that would help us interpret the variations in ID speech. Third, the AD speech was directed toward an unfamiliar adult, whereas the ID speech was directed toward offspring. It is possible that the familiarity of the target listener played a role in the differences we report. Nevertheless, fathers clearly alter their prosody during ID speech in some way, and these variations are likely due to a number of local factors relevant in the immediate communicative context. One possibility is that fathers' exposure to maternal ID speech affects paternal ID speech. If so, we would expect a similar finding for other caregivers or social partners—siblings or grandparents, for example. Future studies could explore whether ID speech of other social partners (e.g., grandparents, siblings) might show similarities to paternal ID speech.

Like many behavioral traits in humans across cultures, the exact forms of a given trait can vary substantially, but the presence of the trait in *some* form is universally manifesting. Spoken language provides the quintessential example of this. There are many reasons that caregivers, including fathers, might alter their speech when addressing infants, and there are different strategies from which to choose. In a free-play context, this is especially true. Future studies would benefit by examining a variety of communicative contexts and integrating rich demographic data with speech data, in an effort to identify particular patterns of interaction—both within and across cultural groups. Alternatively, future work should examine more specific contexts where the caregivers across cultures have more clearly defined communicative goals that predict specific acoustic features, such as controlled prohibitive and approval contexts where pitch loudness parameters are expected to vary systematically. The more researchers constrain the exact communicative goals of the speakers, the more likely we should see consistent behavior across cultures. As it stands, the current work serves to demonstrate that in fact, fathers from a rural, small-scale society produce ID speech

features in a manner that closely resembles what other caregivers around the world have been shown to produce.

References

Barrett, H. C. (2015). *The shape of thought: How mental adaptations evolve*. Oxford, UK: Oxford University Press.

Barton, M. E., & Tomasello, M. (1994). The rest of the family: The role of fathers and siblings in early language development. In C. Gallaway & B. Richards (Eds.), *Input and interaction in language acquisition* (pp. 109–134). New York, NY: Cambridge University Press.

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*, 1–48. doi:10.18637/jss.v067.i01

Boersma, P., & Weenink, D. (2011). *Praat: Doing phonetics by computer (Version 5.2.21) [Computer software]*. Retrieved from http://www.praat.org

Broesch, T., & Bryant, G. (2015). Prosody in infant-directed speech is similar across western and traditional cultures. *Journal of Cognition and Development*, *16*, 31–43. doi:10.1080/15248372.2013.833923

Broesch, T., Rochat, P., Olah, K., Broesch, J., & Henrich, J. (2016). Similarities and differences in maternal responsiveness in three societies: Evidence from Fiji, Kenya and US. *Child Development*, *87*, 700–711. doi:10.1111/cdev.12501

Bryant, G., & Barrett, H. C. (2007). Recognizing intentions in infant-directed speech: Evidence for universals. *Psychological Science*, *18*, 746–751. doi:10.1111/j.1467-9280.2007.01970.x

Bryant, G., Liénard, P., & Barrett, H. C. (2012). Recognizing infant-directed speech across distant cultures: Evidence from Africa. *Journal of Evolutionary Psychology*, *10*, 47–59. doi:10.1556/JEP.10.2012.2.1

Clegg, J. M., & Legare, C. H. (2016). A cross-cultural comparison of children's imitative flexibility. *Developmental Psychology*, *52*, 1435–1444. doi:10.1037/dev0000131

De Jong, N. H., & Wempe, T. (2009). Praat script to detect syllable nuclei and measure speech rate automatically. *Behavior research methods*, *41*, 385–390. doi:10.3758/BRM.41.2.385

Falk, D. (2004). Prelinguistic evolution in early hominins: Whence motherese? *The Behavioral and Brain Sciences*, *27*, 491–541. doi:10.1017/S0140525X04000111

Ferguson, C. (1977). Baby talk as a simplified register. In C. Snow & C. Ferguson (Eds.), *Talking to children* (pp. 219–236). Cambridge, UK: Cambridge University Press.

Fernald, A. (1992). Human maternal vocalizations to infants as biologically relevant signals: An evolutionary perspective. In J. H. Barkow, L. Cosmides, & J. Tooby (Eds.), *The adapted mind: Evolutionary psychology and the generation of culture* (pp. 391–449). New York, NY: Oxford University Press.

Fernald, A., Taeschner, T., Dunn, J., Papousek, M., de Boysson-Bardies, B., & Fukui, I. (1989). A cross-language study of prosodic modifications in mothers' and fathers' speech to preverbal infants. *Journal of Child Language*, *16*, 447–501. doi:10.1017/S0305000090010679

Fouts, H. N. (2008). Father involvement with young children among the Aka and Bofi foragers. *Cross-Cultural Research*, *42*, 290–312. doi:10.1177/1069397108317484

Gergely, G., & Watson, J. S. (1996). The social biofeedback model of parental affect-mirroring. *The International Journal of Psycho-Analysis*, *77*, 1181.

Gleason, J. B. (1975). Fathers and other strangers: Men's speech to young children. In D.P. Dato (Ed.), Language and Linguistics, (pp. 289–297). Washington, D.C.: Georgetown University Press

Halekoh, U., & Højsgaard, S. (2014). A Kenward-Roger approximation and parametric bootstrap methods for tests in linear mixed models—The R package pbkrtest. *Journal of Statistical Software*, *59*, 1–30. doi:10.18637/jss.v059.i09

Hart, B., & Risley, T. R. (2003). The early catastrophe: The 30 million word gap by age 3. *American Educator*, *27*, 4–9.

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *The Behavioral and Brain Sciences*, *33*, 61–83. doi:10.1017/S0140525X0999152X

Hewlett, B. S. (1987). Intimate fathers: Patterns of paternal holding among Aka Pygmies. In M. E. Lamb (Ed.), *The father's role: Cross-cultural perspectives* (pp. 295–330). Hillsdale, NJ: Erlbaum.

Hewlett, B. S. (1991). Demography and childcare in preindustrial societies. *Journal of Anthropological Research*, *47*, 1–37. doi:jstor.org/stable/3630579

Jacobson, J. L., Boersma, D. C., Fields, R. B., & Olson, K. L. (1983). Paralinguistic features of adult speech to infants and small children. *Child Development*, *54*, 436–442. doi:10.2307/1129704

Kaplan, P. S., Sliter, J. K., & Burgess, A. P. (2007). Infant-directed speech produced by fathers with symptoms of depression: Effects on infant associative learning in a conditioned-attention paradigm. *Infant Behavior and Development*, *30*, 535–545. doi:10.1016/j.infbeh.2007.05.003

Keller, H. (2013). Attachment and culture. *Journal of Cross-Cultural Psychology*, *44*, 175–194. doi:10.1177/0022022112472253

Keller, H., Kärtner, J., Borke, J., Yovsi, R., & Kleis, A. (2005). Parenting styles and the development of the categorical self: A longitudinal study on mirror self-recognition in Cameroonian Nso and German families. *International Journal of Behavioral Development*, *29*, 496–504. doi:10.1080/01650250500147485

Kreiman, J., & Sidtis, D. (2011). *Foundations of voice studies: An interdisciplinary approach to voice production and perception*. Hoboken, NJ: Wiley-Blackwell.

Kuhl, P. K., Andruski, J. E., Chistovich, I. A., Chistovich, L. A., Kozhevnikova, E. V., Ryskina, V. L., . . . Lacerda, F. (1997). Cross-language analysis of phonetic units in language addressed to infants. *Science*, *277*, 684–686. doi:10.1126/science.277.5326.684

Lamb, M. E. (Ed.). (2013). *The father's role: Cross-cultural perspectives*. Hillsdale, NJ: Erlbaum.

Lamb, M. E., Pleck, J. H., Charnov, E. L., & Levine, J. A. (1987). A biosocial perspective on paternal behavior and involvement. In J. Lancaster, J. Altmann, A. Rossi, & L. Sherrod (Eds.), *Parenting across the life span: Biosocial dimensions* (pp. 111–142). Hawthorne, NY: Aldine.

Lancy, D. F. (2010). Learning "from nobody": The limited role of teaching in folk models of children's development. *Childhood in the Past: An International Journal*, *3*, 79–106. doi:10.1179/cip.2010.3.1.79

Lancy, D. F. (2016). Playing with knives: The socialization of self-initiated learners. *Child Development*, *87*, 654–665. doi:10.1111/cdev.12498

Lefcheck, J. S. (2015). PiecewiseSEM: Piecewise structural equation modeling in R for ecology, evolution, and systematics. *Methods in Ecology and Evolution*, *7*, 573–579. doi:10.1111/2041-210X.12512

Legare, C. H., & Harris, P. L.(Eds). (2016). The ontogeny of cultural learning (Special Section). *Child Development*, *87*, 633–833. doi:10.1016/j.copsyc.2015.09.008

LeVine, R., Dixon, S., LeVine, S., Richman, A., Leiderman, P. H., Keefer, C. H., & Brazelton, T. B. (1994). *Childcare and culture: Lessons from Africa*. Cambridge, UK: Cambridge University Press.

Little, E. E., Carver, L. J., & Legare, C. H. (2016). Cultural variation in triadic infant–caregiver object exploration. *Child Development*, *87*, 1130–1145. doi:10.1111/cdev.12513

Malin, J. L., Karberg, E., Cabrera, N. J., Rowe, M., Cristaforo, T., & Tamis-LeMonda, C. S. (2012). Father–toddler communication in low-income families: The role of paternal education and depressive symptoms. *Family Science*, *3*, 155–163. doi:10.1080/19424620.2012.779423

McLaughlin, B., White, D., McDevitt, T., & Raskin, R. (1983). Mothers' and fathers' speech to their young children: Similar or different? *Journal of Child Language*, *10*, 245–252.

Mehler, J., Bertoncini, J., Barrière, M., & Jassik-Gerschenfeld, D. (1978). Infant recognition of mother's voice. *Perception*, *7*, 491–497. doi:10.1068/p070491

Morton, E. S. (1977). On the occurrence and significance of motivation-structural rules in some bird and mammal sounds. *The American Naturalist*, *111*, 855–869. doi:10.1086/283219.

Nakagawa, S., & Schielzeth, H. (2013). A general and simple method for obtaining R^2 from generalized linear mixed-effects models. *Methods in Ecology and Evolution*, *4*, 133–142. doi:10.1111/j.2041-210x.2012.00261.x

Nelson, D. G. K., Hirsh-Pasek, K., Jusczyk, P. W., & Cassidy, K. W. (1989). How the prosodic cues in motherese might assist language learning. *Journal of Child Language*, *16*, 55–68. doi:10.1017/S030500090001343X

Nielsen, M., & Haun, D. (2016). Why developmental psychology is incomplete without comparative and cross-cultural perspectives. *Philosophical Transactions of the Royal Society of London Series B, Biological Sciences*, *371* (1686). 1–7. doi: 10.1098/rstb.2015.0071

Odden, H., & Rochat, P. (2004). Observational learning and enculturation. *Educational and Child Psychology*, *21*, 39.

Owren, M., & Rendall, D. (2001). Sound on the rebound: Bringing form and function back to the forefront in understanding nonhuman primate vocal signaling. *Evolutionary Anthropology: Issues, News, and Reviews*, *10*, 58–71. doi:10.1002/evan.1014

Papoušek, M., Papoušek, H., & Haekel, M. (1987). Didactic adjustments in fathers' and mothers' speech to their 3-month-old infants. *Journal of Psycholinguistic Research*, *16*, 491–516. doi:10.1007/BF01073274

Pancsofar, N., & Vernon-Feagans, L.; The Family Life Project Investigators (2010). Fathers' early contributions to children's language development in families from low-income rural communities. *Early Childhood Research Quarterly*, *25*, 450–463. doi:10.1016/j.ecresq.2010.02.001

Pegg, J. E., Werker, J. F., & McLeod, P. J. (1992). Preference for infant-directed over adult-directed speech: Evidence from 7-week-old infants. *Infant Behavior and Development*, *15*, 325–345. doi:10.1016/0163-6383(92)80003-D

R Core Team. (2015). *R: A language and environment for statistical computing R Foundation for statistical computing*, Vienna, Austria. Retrieved from http://wwwR-projectorg/

Ratner, N. B., & Pye, C. (1984). Higher pitch in BT is not universal: Acoustic evidence from Quiche Mayan. *Journal of Child Language*, *11*, 515–522. doi:10.1017/S0305000900005924

Rochat, P., Dias, M. D., Liping, G., Broesch, T., Passos-Ferreira, C., Winning, A., & Berg, B. (2009). Fairness in distributive justice by 3-and 5-year-olds across seven cultures. *Journal of Cross-Cultural Psychology*, *40*, 416–442. doi:10.1177/0022022109332844

Rondal, J. A. (1980). Fathers' and mothers' speech in early language development. *Journal of Child Language*, *7*, 353–369. doi:10.1017/S0305000900002671

Rowe, M. L., Coker, D., & Pan, B. A. (2004). A comparison of fathers' and mothers' talk to toddlers in low income families. *Social Development*, *13*, 278–291. doi:10.1111/j.1467-9507.2004.000267.x

Scelza, B. A., Bryant, G., & Cartmill, E. (2014, December). *Effects of age and experience on the use of infant-directed communication*. Paper presented at the Annual Meeting of the American Anthropological Association, Washington, DC.

Senju, A., & Csibra, G. (2008). Gaze following in human infants depends on communicative signals. *Current Biology*, *18*, 668–671. doi:10.1016/j.cub.2008.03.059

Shute, B., & Wheldall, K. (1989). Pitch alterations in British motherese: Some preliminary acoustic data. *Journal of Child Language*, *16*, 503–512. doi:10.1017/S0305000900010680

Shute, B., & Wheldall, K. (1999). Fundamental frequency and temporal modifications in the speech of British fathers to their children. *Educational Psychology*, *19*, 221–233. doi:10.1080/0144341990190208

Snow, C., & Ferguson, C. (1977). *Talking to children: Language input and acquisition*. Cambridge, UK: Cambridge University Press.

Thiessen, E. D., Hill, E. A., & Saffran, J. R. (2005). Infant-directed speech facilitates word segmentation. *Infancy*, *7*, 53–71. doi:10.1207/s15327078in0701_5

Titze, I. R. (2000). *Principles of voice production* (pp. 149–184). Iowa City, IA: National Center for Voice and Speech.

Tomasello, M. (2009). *Constructing a language: A usage-based theory of language acquisition*. Cambridge, MA: Harvard University Press.

Warren-Leubecker, A., & Bohannon, III, J. N. (1984). Intonation patterns in child-directed speech: Mother-father differences. *Child Development*, *55*, 1379–1385. doi:10.2307/1130007

Werker, J. F., & McLeod, P. J. (1989). Infant preference for both male and female infant-directed talk: A developmental study of attentional and affective responsiveness. *Canadian Journal of Psychology*, *43*, 230–246. doi:10.1037/h0084224

Whiting, B., & Whiting, J. W. M. (1975). *Children of six cultures: A psycho-cultural analysis*. Cambridge, MA: Harvard University Press.

Supporting Information

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

Appendix S1. Verbal Instructions to Parents