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Changes in Parental Prosody Mediate Effect of Parent-Training Intervention on Infant Language Production

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Abstract

Objective: Parent-training interventions to reduce behavior problems in young children typically coach parents on the content of their speech, but rarely assess parents' prosody during parent–child interactions. Infant-directed speech helps shape the parent–infant relationship and promote language development, which predicts adaptive behavioral outcomes in children. The current study examined (a) the effect of a parent-training intervention on parents' vocal cues in interactions with their infant and (b) whether parental prosody mediated the impact of the intervention on infant language production.

Method: Sixty families with 12- to 15-month-old infants (47% female; 95% of Hispanic/Latino ethnicity) participated in the Infant Behavior Program (IBP), a brief home-based adaptation of Parent–Child Interaction Therapy, or received standard pediatric care. Speech analysis was performed on mothers' (n = 40) utterances during infant-led play pre- and postintervention. Infants' number of utterances spoken during play was assessed at pre- and postintervention, and at 3- and 6-month follow-ups.

Results: Mothers who received the IBP spoke with greater pitch range and slower tempo postintervention, when controlling for baseline prosody. Change in these vocal cues, which are typical of infant-directed speech, mediated the effect of the intervention on infants' word production after 6 months.

Conclusions: Interventions targeting the content of parents' speech during parent–infant interactions may lead to changes in parental prosody, which may be beneficial for infants' language development. Impaired linguistic abilities in infancy are strongly associated with

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behavior problems in later childhood; thus, these findings highlight a potential mechanism for intervention efficacy in promoting positive socioemotional and behavioral outcomes.

Keywords

infant-directed speech; language development; parent-training intervention; prosody

Interventions focusing on parent–child interactions (e.g., Parent-Child Interaction Therapy [PCIT]; Zisser & Eyberg, 2010) aim to decrease problematic child behaviors by promoting a positive parent–child relationship. Adaptations of these programs for use with infants(i.e., children 0 to 3 years old; Zeanah & Zeanah, 2001), such as the Infant Behavior Program (IBP; Bagner, Rodríguez, Blake, & Rosa-Olivares, 2013), are effective in increasing positive parental verbalizations, warmth, and sensitivity in the parent–infant relationship (Bagner, Coxe, et al., 2016; Blizzard, Barroso, Ramos, Graziano, & Bagner, 2017). However, though previous studies quantify *what* parents say, little attention is typically given to *how* they say it. Because parents' prosody, or tone of voice, during infant-directed speech (IDS) plays an important role in the parent-infant relationship at an early age (Saint-Georges et al., 2013), understanding how parent-training programs may alter parents' use of IDS can shed light on mechanisms for long-term intervention efficacy.

IDS, or "motherese," functions to facilitate language acquisition, communicate affect, promote social interaction, and attract infants' attention (Golinkoff, Can, Soderstrom, & Hirsh-Pasek, 2015). IDS is characterized by a particular lexicon, altered sentence constructions, and specific paralinguistic cues (Ferguson, 1964; Soderstrom, 2007). These vocal cues, which include a slower tempo, higher pitch, and greater range in pitch (Grieser & Kuhl, 1988; Saint-Georges et al., 2013), are particularly important for infants' socioemotional, behavioral, cognitive, and linguistic development (Spinelli, Fasolo, & Mesman, 2017). Indeed, infants of parents who do not employ IDS prosody as frequently, such as depressed mothers, are more likely to show impaired associative learning (Kaplan, Bachorowski, Smoski, & Hudenko, 2002).

The first goal of this study was to examine whether participation in a parent-training intervention (IBP) led to increases in parents' use of IDS prosody (i.e., greater pitch mean and range, slower tempo) during infant-led play. The IBP aims to improve the quality of parent-infant interactions, reduce infant disruptive behaviors, and increase infant prosocial behaviors by ameliorating parenting skills. As in PCIT, parents are encouraged to use specific speech content (e.g., praise, reflective statements) and to demonstrate enjoyment in play with their infant, but the vocal tone parents use is neither targeted by the intervention nor measured as an outcome. Given that the vocal cues of IDS overlap to some extent with the expression of warmth and tenderness (Juslin & Laukka, 2003; Trainor, Austin, & Desjardins, 2000), we hypothesized that parents who received the IBP would increase their use of IDS prosody when communicating with their infant (i.e., greater pitch mean and range, slower tempo) postintervention more than parents who received standard pediatric care. We answered this question by performing speech analysis on parents' utterances during infant-led play at pre- and postintervention.

The second goal of this study was to examine whether parents' vocal cues during play with their infant mediated the effect of the IBP on infant language. Early linguistic ability is an important index of adaptive development. For instance, language impairments in preschool have been associated with behavioral problems and peer rejection (Ketelaars, Cuperus, Jansonius, & Verhoeven, 2010; McCabe, 2005; Menting, Van Lier, & Koot, 2011). Further, language ability in early childhood uniquely predicted later impulsivity-hyperactivity and externalizing problems in early adolescence (Petersen et al., 2013), suggesting that early language skills may prevent later psychosocial difficulties (Snowling, Bishop, Stothard, Chipchase, & Kaplan, 2006). The IBP led to improvements in infant language (Bagner, Garcia, & Hill, 2016), an effect that was mediated by parents' positive verbalizations (Garcia, Bagner, Pruden, & Nichols-Lopez, 2015). Beyond the effect of parents' speech content that is targeted by the intervention, the *tone of voice* parents use while talking to their child may also be important in producing change in children's outcomes. Indeed, above and beyond the overall amount of speech input a child is exposed to, the quantity and quality of IDS children hear strongly predicts their later language development (Cristia, 2013; Zauche, Thul, Mahoney, & Stapel-Wax, 2016). For instance, the amount of experimenter-rated IDS in 11- and 14-month-old infants' interactions with their parents predicted parent-reported word production at 24 months (Ramírez-Esparza, García-Sierra, & Kuhl, 2014). Thus, we predicted that the vocal cues of IDS would mediate the effect of the IBP on infants' observed word production.

Method

Participants

Sixty families of infants aged 12 to 15 months who scored above the 75th percentile on the problem scale of the Brief Infant-Toddler Social and Emotional Assessment (Briggs-Gowan & Carter, 2006) were recruited in pediatric primary care. Parents consented to participate in a randomized control trial on the efficacy of the IBP (Bagner, Coxe, et al., 2016). Of the 60 families randomly assigned to receive the IBP intervention ($n = 31$) or standard pediatric care ($n = 29$), 58 completed a baseline assessment in their home (Time 1), which included an observation of infant-led play. Further observations of play were conducted at postintervention 2 months later (Time 2), and 3 (Time 3) and 6 (Time 4) months after the postintervention assessment. Primary caregivers (all mothers) spoke English (42%) or Spanish (58%). Infants were on average 13 months of age ($M = 13.52$, $SD = 1.30$), 46.6% female, and 94.8% of Hispanic/Latino ethnicity. Most families (60%) reported incomes below the poverty line. Control and intervention families did not differ on infant age, $t(56) = -1.53$, $p = .13$, sex ($p = .79$; Fisher's exact test), ethnicity ($p = .24$, FET), caregiver language ($p = .07$, FET), or poverty status ($p = .79$, FET; Table 1).

Intervention

The IBP is a brief home-based adaptation of PCIT (Zisser & Eyberg, 2010) that emphasizes the use of appropriate parenting skills during play (Bagner, Coxe, et al., 2016). Parents were taught to use "PRIDE" skills (i.e., praise their infant, reflect their speech, imitate their play, describe their behavior, and express enjoyment during play), and to ignore disruptive behaviors. Therapists worked with the family for five to seven weekly sessions (see Bagner,

Coxe, et al., 2016 for details). Procedures were approved by university and hospital ethics review boards.

Measures

Speech analysis.—Audio was extracted from videotaped observations of 5-min parent–infant interactions. Speech analysis data were available for 40 families (15 intervention and 25 control families), as a result of attrition (11 intervention families) and missing speech data (two intervention families had corrupted audio recordings, and five mothers [three control] produced no utterances at Time 2). Families with and without speech data did not differ on infant age, $t(55) = 0.17$, $p = .87$, sex ($p = .57$, FET), ethnicity ($p = .55$, FET), caregiver language ($p = .16$), or poverty status ($p = .57$, FET). Segments of mothers' voices in the audio recordings were demarcated in Praat (Boersma & Weenink, 2015). The coder (M.M.) was masked to families' intervention status during coding. Because recordings were obtained in a naturalistic environment, mothers' utterances were separated into voiced segments and noise (e.g., containing infant vocalizations or background noise). Using Praat, we extracted pitch variables (mean pitch, pitch range)[1] and duration (proxy for tempo)[2] from each voiced segment. Duration values were obtained for all 40 mothers. Pitch variables were obtained for 37 mothers (utterances by two control and one intervention mothers were unvoiced). Acoustic cue values were averaged across all utterances to obtain a global value for each mother, to account for any discrepancy in the number of utterances produced by different mothers.

Language production.—Infants' language production was measured at all time points by coding infants' linguistic productions with the Child Language Data Exchange System (CHILDES; MacWhinney, 2000), a widely used and psychometrically valid tool to examine child language (Corrigan, 2011). The number of different ("unique") utterances spoken by the infant during play, which represents lexical diversity, was coded using the CHILDES computerized language analysis tool (details in Bagner, Coxe, et al., 2016).

Statistical Analysis

An analysis of covariance was performed to examine the effect of intervention group (intervention versus control) on mothers' Time 2 vocal cues, covarying for Time 1 vocal cues (Rausch, Maxwell, & Kelley, 2003). A separate model was conducted for each cue (pitch mean, pitch range, duration). Second, we examined whether mothers' Time 2 vocal cues mediated the association between group and infants' produced words at Time 3. To control for baseline speech patterns and infant language, Time 1 vocal cues and word

[1]Mean pitch, or fundamental frequency (F0), relates to how high or low a given speaker's voice sounds overall. Pitch range represents the degree to which pitch varies over a specific segment. The mean, minimum, and maximum pitch in Hertz (Hz) were obtained from each voiced segment's waveform using autocorrelation (time step = 0.0 s, pitch floor = 75 Hz, pitch ceiling = 400 Hz). Pitch range was computed by subtracting the minimum from the maximum pitch point within each voiced segment (Spinelli et al., 2017).

[2]The duration of voiced segments was extracted as a proxy for speech rate. Speech rate is typically computed by dividing the duration of segments by the number of words in the spoken utterance (Johnstone & Scherer, 2000). However, because of environmental noises that interrupted speech and resulted in unintelligible segments, we could not compute the number of produced words precisely. Using the intelligible utterances that were available, we estimated each mother's average speech rate (number of words per utterance/length of utterance in minutes). Speech rate was negatively correlated with utterance duration ($r = -.25$, $p = .13$ at Time 1, and $r = -.40$, $p = .01$ at Time 2), suggesting that longer utterances were indeed associated with a slower speech rate (i.e., smaller speech rate value in words/min).

production were entered as covariates to the mediator and outcome variables, respectively. We conducted an identical model with infants' produced words at Time 4 as the dependent variable. Of the 40 families with speech data, 33 (12 intervention, 21 control) had language production data at Time 3 and/or Time 4 and were included in the mediation analyses (missing data due to attrition). All variables were screened for skewness and kurtosis; distributions were sufficiently normal. No families were identified as multivariate outliers based on the Malahanobis distance ($df = 9$; all ps > .001).

Results

Descriptive statistics about parental vocal cues and infant language production are provided in Table 2. The ANCOVA on the association between group and Time 2 vocal cues, covarying for Time 1 cues, revealed significant effects for pitch range, $F(1,34) = 4.84$, $p = .04$, $\eta^2 = .13$, and for duration, $F(1, 37) = 7.11$, $p = .01$, $\eta^2 = .16$. No significant effect of group was found for pitch mean ($p = .40$, $\eta^2 = .02$). When controlling for baseline vocal cues, mothers in the intervention group spoke with a greater range in pitch and longer utterances (prosodic variations associated with IDS) than the control group postintervention.

Mediation analyses did not reveal direct or indirect effects of Time 2 vocal cues on Time 3 infant word production (see Figure 1). Vocal cues mediated the association between group and word production at Time 4 (see Figure 2). In this model, participating in the intervention was a significant predictor of greater Time 2 pitch range, $B = 21.23$, $SE = 9.40$, $p = .03$, 95% CI [2.02, 40.43], and greater Time 2 duration, $B = 0.16$, $SE = 0.05$, $p < .01$, 95% CI [0.05, 0.27]. Time 2 duration predicted higher production of different words at Time 4, $B = 36.36$, $SE = 17.42$, $p < .05$, 95% CI [0.68, 72.04], controlling for Time 1 word production. As expected in mediation, group did not directly predict Time 4 word production ($p = .98$), but there was a significant indirect effect through Time 2 duration, $B = 5.82$, $SE = 4.24$, 95% CI [0.61, 16.89].

Discussion

The current study is the first to examine the effect of a parent-training intervention on parental vocal prosody during interactions with their infants. Mothers who participated in the intervention spoke with greater pitch range and slower tempo than mothers in the control group postintervention. These vocal cues, which are consistent with the prosodic patterns of IDS, mediated the effect of the intervention on infants' gain in word production at a 6 month follow-up. Parents' use of IDS has been robustly linked to adaptive socioemotional, cognitive, and linguistic development in infants (Saint-Georges et al., 2013), the latter of which has been associated with positive behavioral outcomes in later childhood (Menting et al., 2011; Petersen et al., 2013). As such, our findings suggest that parents' use of IDS prosody in interactions with their infant may be an important mechanism for long-term intervention efficacy.

Postintervention changes in mothers' prosody were noted even though mothers were not coached on *how* to speak to their infant—only about what to say. Mothers who implemented the IBP's recommendation to praise their infants' behaviors may have instinctively done so

using IDS vocal patterns, which have been associated with the expression of warmth and tenderness (Juslin & Laukka, 2003; Trainor et al., 2000).[3] IBP interventionists also may have modeled the use of IDS when demonstrating positive communicative styles. Future work should investigate whether adding explicit encouragement for parents to use these prosodic cues to the standard intervention protocol would enhance outcomes even more.

It is well-established that parents' use of IDS facilitates infants' language development (Rowe, 2008). In the current study, IDS prosody mediated the association between the intervention and greater infant word production 6 months postintervention, via the impact of a slower speech tempo. Hyperarticulated vowel pronunciation is thought to facilitate infants' word understanding (Cristia, 2013), suggesting that the slow pace of IDS may be particularly important for promoting language development in infants. Of note, the mediating effect of duration on the association between IBP and word production was only significant at Time 4, when infants were between 18 and 24 months of age. This coincides with the timing of peak language acquisition (McMurray, 2007). Thus, the effect of IDS' tempo on word production may only be evident once infants are old enough to produce speech consistently. It will be important to investigate the time course of IDS' effectiveness on infant outcomes, as various aspects of parental speech may become relevant to language development at different time points across infancy and early childhood (Golinkoff et al., 2015).

Because recordings of parents' speech were obtained in naturalistic settings (i.e., in the home), these findings represent an estimate of the real-life impact of parent-training interventions on parent–infant interactions and infant language. However, this approach reduces the specificity of the speech analysis that can be conducted. Environmental noise and lack of acoustic control prevented the computation of vocal intensity and of other syntactic and phonological characteristics of IDS, like vowel lengthening (Soderstrom, 2007). Moreover, the sample size for this study was relatively small, in part because of expected attrition in a longitudinal design, as well as limitations on the available acoustic data. Further, many families for whom speech analysis was feasible spoke Spanish (65%), but the sample size was insufficient to examine whether caregiver language moderated the effects. Though IDS is similar in vocal characteristics across many languages, including Spanish (Blount & Padgug, 1977; Soderstrom, 2007), replication of this preliminary work in a larger sample will be important.

In conclusion, the current study suggests that parents' use of IDS prosody in interactions with their infant may be a mechanism for positive change in infant language development following parent training. Parents' IDS and early linguistic ability have both been linked to adaptive social and cognitive development in infancy and beyond (McCabe, 2005; Saint-Georges et al., 2013). As such, harnessing parents' natural tendency toward "motherese" in infancy may improve their young children's socioemotional and behavioral adjustment, though additional research is needed. Understanding the mechanisms underlying the efficacy of parent-training programs is crucial to replicate and expand intervention efforts.

[3]Indeed, follow-up analyses suggested that increased praise utterances were significantly associated with the use of wider pitch range ($r = .33$, $p = .04$) and slower speech rate ($r = .42$, $p = .01$) at postintervention (details available from first author).

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What is the public health significance of this article?

Interventions targeting parent behaviors in the context of the parent–infant relationship may promote the use of infant-directed speech prosody. Parents' use of these vocal cues may be beneficial for infants' language development, which has been associated with adaptive socioemotional and behavioral outcomes in later childhood.

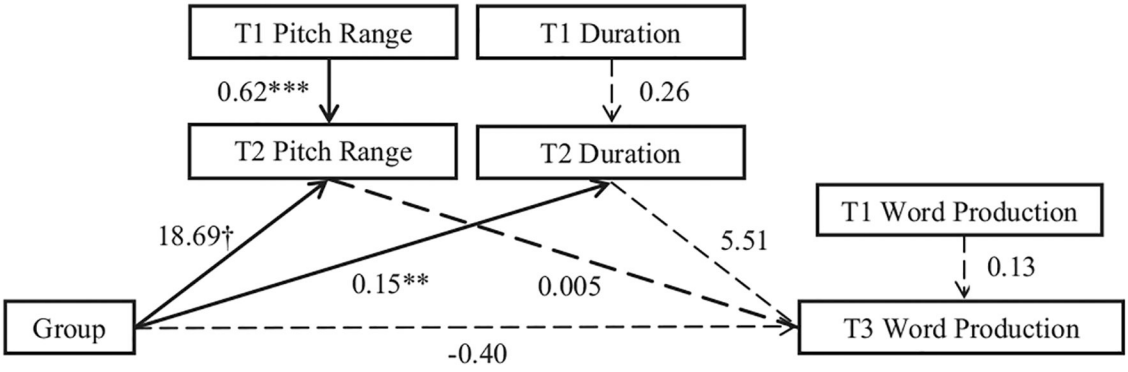

Figure 1.

Model for mediating effect of parents' vocal cues (pitch range and duration) at Time 2 on the group's (intervention versus control) effect on infants' word production at Time 3, controlling for parents' baseline vocal cues and infants' baseline word production at Time 1. Unstandardized regression coefficients are represented on each path. Solid lines represent significant relationships. ** $p < .01$. *** $p < .001$. † Marginal significance.

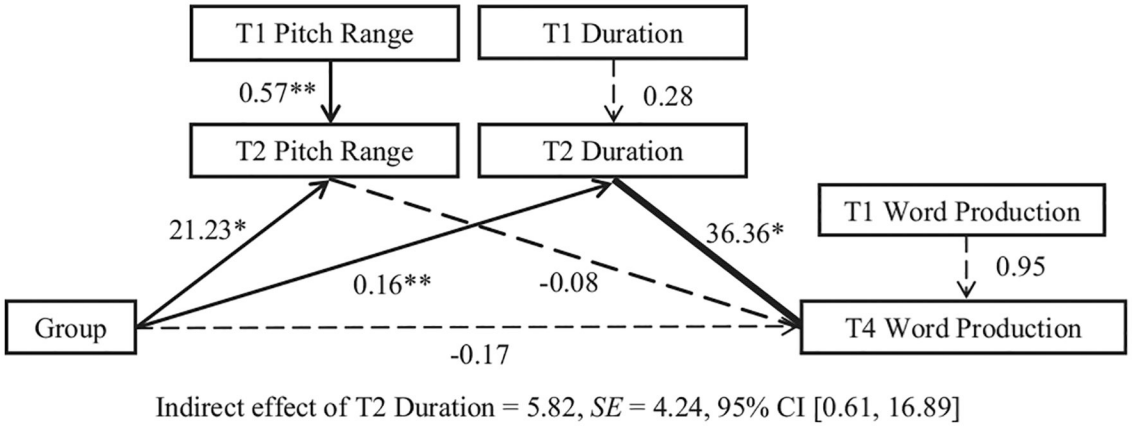

Figure 2.

Model for mediating effect of parents' vocal cues (pitch range and duration) at Time 2 on the group' (intervention versus control) effect on infants' word production at Time 4, controlling for parents' baseline vocal cues and infants' baseline word production at Time 1. Unstandardized regression coefficients are represented on each path. Solid lines represent significant relationships. * $p < .05$. ** $p < .01$.

Table 1

Demographic Characteristics of Intervention and Control Families

Characteristic	Intervention families (*n* = 31)	Control families (*n* = 29)
Mean infant age in months (*SD*)	13.77 (1.38)	13.25 (1.18)
Infant gender	13 female	14 female
Infant ethnicity	27 Hispanic or Latino	28 Hispanic or Latino
Caregiver language	14 Spanish	20 Spanish
Poverty status	17 below poverty line	17 below poverty line

Note. SD = standard deviation. Values are provided for the 58 families who participated in Time 1 baseline assessments.

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Table 2

Descriptive Statistics of Parental Vocal Cues and Infant Word Production

Measure	Intervention families *M (SD)*	Control families *M (SD)*
Vocal cues		
Time 1 pitch mean	247.94 (30.47)	238.78 (30.05)
Time 1 pitch range	70.54 (18.93)	65.37 (31.52)
Time 1 duration	0.58 (.14)	0.51 (.19)
Time 2 pitch mean	252.27 (25.92)	237.64 (25.38)
Time 2 pitch range	76.29 (32.02)	58.32 (30.48)
Time 2 duration	0.64 (.16)	0.49 (.15)
Infant language outcomes		
Time 1 word production	1.00 (1.77)	0.76 (.83)
Time 3 word production	2.86 (4.75)	2.36 (3.90)
Time 4 word production	16.29 (12.87)	11.64 (13.95)

Note. SD = standard deviation. Values are provided for the 40 families for whom speech analysis was feasible.