Exploring the Association of Infant Temperament on Maternal Fundamental Frequency Contours

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Abstract

The current study looked at the association between infant temperament and mothers' infant-directed speech regarding adaptations to fundamental frequency (F_o) contours. F_o contours regulate infant attention and affect, and are classified into four contours: rising, bell-shaped, slowly-falling, and rapidly-falling. Eight mother-infant dyads were recruited and participated in a 15-minute play interaction, and mothers' F_o contours were extracted. Infant temperament was assessed using the Temperamental Adjective Triad Assessment. Significant correlations were found between infant approach and rising contours, and infant mood and slowly-falling contours, suggesting evidence of a relationship between infant temperament and mother's F_o contours.

Index Terms: Infant temperament, F_o contours, Infant-directed speech

1. Introduction

Temperament is the differences in reactivity and regulation displayed by an infant, and can include dimensions such as activity, approach to novelty, quality and intensity of mood and attention [1, 2, 3, 4]. An infant's temperamental characteristics are thought to influence the mother-infant interaction, including the mother's linguistic communication [5, 6]. Mothers who speak to their infant automatically use infant-directed speech (IDS), which is a unique speech register characterised by specific semantic and acoustic properties suggested to be fundamental to infant development [7, 8, 9, 10]. It is posited that infant temperament is related to maternal IDS [7, 11, 12]. The current study aimed to look at the association of infant temperament and maternal IDS. Specifically, this study aimed to investigate whether the infant's temperament was associated with an important aspect of the mother's IDS; her fundamental frequency (F_o) contours.

In relation to infant temperament, two functions of IDS are particularly important: attention regulation and affect communication [13, 14]. Attention in infancy generally refers to visual attention, whereby infants demonstrate the ability to track and disengage from a stimulus, orient to a location, and anticipate visual events [15]. Infants display heightened attention when addressed with IDS compared to Adult-Directed Speech (ADS) [9, 16]. Infant attention is also related to affective information, where positive vocalisations elicit infant attention [17].

Affective communication is potentially the most salient function of IDS. Infant affect is expressed through vocalisation, facial expression, and bodily movements, and these expressions normally elicit responses mothers in order to regulate an infant's affect [18]. This affective regulation function in IDS seems to be the most prominent component early on, particularly in the first 12 months [7, 19, 20].

One important difference in IDS compared to ADS involves F_o, which is generally associated with the percept of pitch [21]. F_o is the most salient property of IDS and is predominantly responsible for infant preference for IDS over ADS [11, 22, 23, 24, 25, 26]. Both the attentional and affective function of IDS are largely conveyed by adaptations mothers make using F_o contours [10, 27]. F_o contours typically have one of four shapes when visually represented: rising, bell-shaped, slowly-falling, and rapidly-falling (see Fig.1) [25, 28]. The F_o contour a mother uses corresponds to her communicative intent, which is usually adapted by the mother to bring the infant into an optimal state of arousal and attention [9, 27, 28, 29]. Specifically, rising and bell-shaped contours are associated with positive affect and attaining or maintaining attention, whereas slowly-falling contours are associated with soothing negative affect in infants [25]. Rapidly-falling contours are used as a prohibition against unwanted behaviour.

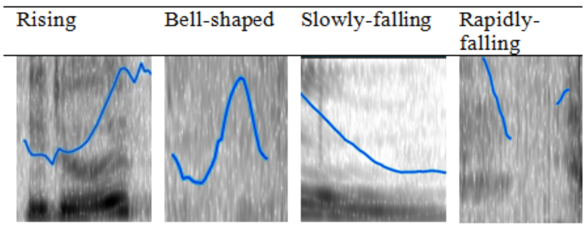

Figure 1: *Typical F_o contours used by the mothers in the current study, the line depicts the F_o contour.*

The occurrences of these four contours have been comprehensively investigated in terms of the mother's side of the communicative interaction [25]. The infant's potential contribution to the mother-infant interaction, however, has not been examined in as much detail. Furthermore, there are few studies that investigate more than one temperamental characteristic in relation to IDS [9, 30], and no previous studies looking at the association between multiple infant temperamental dimensions and the mother's F_o contours.

The current study investigates whether the infant's mood, activity, approach, and intensity are associated with the

F_o contours the mother uses. It is hypothesised that when an infant displays a temperamental trait related to affect or attention, the mother will be more likely to use a F_o contour typically used to communicate affect or regulate attention.

Specifically, we hypothesised that attention-grabbing rising and attention-maintaining bell-shaped contours would be associated with infants who show higher levels of activity and approach. Rising and bell-shaped contours are also assumed to convey positive affect, and as such are expected to be related to high or positive levels of infant mood. Slowly-falling contours that are associated with soothing properties are predicted to be related to a low or negative mood. Rapidly-falling contours, that prohibit unwanted behaviour, are expected to be related to infants displaying a low or negative mood and high levels of activity and approach.

The present study tests a sample of 6-months-old infants, as studies suggest that infants at this age express more emotion and interest compared to older ages [31].

2. Method

2.1 Participants

Infants were recruited through the Breathing for Life Trial-Infant Development (BLT-ID) study, which is investigating the effects of maternal asthma on infant development during the first 12 months of infancy. Eight mothers and their 6-month-old (±30 days) infants (four girls; four boys) participated in the present sub-study, which was undertaken at the Hunter Medical Research Institute (HMRI). The infants did not suffer from any known hearing impairment and mothers consented prior to participation.

2.2 Measures and Equipment

Infant temperament was assessed with the Temperament Adjective Triad Assessment (TATA) [4]. The TATA requires the experimenter to rate the infant on four dimensions of behaviour; Mood, Activity, Approach, and Intensity [4, 32]. These behaviours are represented by 13 items, rated on a Likert scale from 1 to 5, representing opposing polarities. For example, the infant would be rated on the mood subscale from 'Happy/jubilant/cheerful' (1) to 'Sad/Blue/unhappy' (5).

Audio recordings of the mother's speech were made with a Sennheiser ew112 G3 wireless clip-on lapel microphone connected to the mother's clothing to ensure freedom of movement. The microphone sent recordings to an EW100G3 adaptive diversity receiver and a Roland R-26 portable recorder. The speech stream was recorded alongside four video recordings of the interaction captured by Sony HDR-CX405 handycams.

2.3 Procedure

Mothers were informed that the study was investigating how mothers interacted with their children. The mother and infant were seated on a play mat on the floor of the testing room. The mother was given standardised instructions to interact with her infant in as 'natural a way as possible' for 15 minutes. The first 7.5 minutes of the interaction consisted of free-play. After 7.5 minutes, the experimenter placed specific toys chosen for 6 month old infants within the mother's reach for her to interact with her infant in order to facilitate IDS.

2.4 Coding

Two undergraduate students trained in assessment using the TATA rated the infants independently using a scoring template on the four dimensions of temperament; Mood, Activity, Approach, and Intensity. The mean of the raters' scores was used, giving the infant four scores on each of the temperament dimensions.

The audio recordings of the entire interaction were converted into WAV files to be orthographically transcribed and analysed using Praat 5.3.51 [33]. The speech samples were broken down into utterances from the mother, defined as segments of speech separated by more than 300 milliseconds of non-speech [24]. Any utterances that were interrupted by non-speech sounds were omitted from analysis. The F_o contours were extracted from the utterances and graphically rendered in Praat [33]. The coding procedure for classification of F_o contours was adapted from those used in previous studies [28]. A total of 1884 F_o contours were visually classified by a trained researcher into one of the four categories: rising, bell-shaped, slowly-falling, and rapidly-falling. Only two contours were excluded as they were too ambiguous to be classified.

2.5 Design and Analysis

The current study was a cross-sectional exploratory correlational analysis. The data were statistically analysed using the Statistical Package for the Social Sciences [34]. The contours were separated into a 'no toy' and 'toy' condition. We computed per mother, per condition, the proportion of each of the four contours relative to all contours. A Shapiro-Wilk test of normality was conducted on the contour and temperament data sets. Depending on normality, either Pearson's or Spearman's correlations were run on the TATA scores and mothers' F_o contours, to determine if any associations existed between the TATA scores and the proportion of each of the contours.

3. Results

Correlation coefficients for the proportion of each contour class and the infant temperament dimensions are reported in Table 1 for both the 'toy' and 'no toy' conditions.

3.1 Rising contours and Infant Temperament

Contrary to the hypothesis, the mothers' proportion of rising contours in either toy condition was not significantly related to either the infants' mood or activity level (see table 1). Although, a trend emerged for fewer rising contours to be used when the infant displayed a more negative mood or less activity. A significant negative correlation was found, however, in the toy condition between the proportion of rising contours and approach (r_s= .690, N= 8, p= .029; see table 1).

3.2 Bell-shaped contours and Infant Temperament

The mothers' proportion of bell-shaped contours were hypothesised to be associated with infants' mood, activity,

Table 1. *Correlations of Mothers' F_0 Contours in the two Toy Conditions and the Infants' TATA Dimension Scores*

	Rising		Bell-Shaped		Slowly-falling		Rapidly-falling	
	No Toy	Toy	No Toy	Toy	No Toy	Toy	No Toy	Toy
Mood	$-.382_s$	$-.497_s$	$.096_s$	$-.491_s$	$.695\,*_s$	$.715\,*_s$	$-.544_s$	$-.043_s$
Activity	$.012_s$	$-.422_s$	-.605	-.498	.697*	.495	$.065_s$	$-.074_s$
Approach	$.036_s$	$-.648\,*_s$	$-.347_s$	$-.551_s$	$.571_s$	$.794\,**_s$	$-.274_s$	$-.068_s$
Intensity	$-.711\,*_s$	$.466_s$	.081	-.383	.561	-.193	$.222_s$	$.235_s$

Note. * indicates a significant correlation at a .05 value, ** indicates a significant correlation at a .01 value, *s* indicates Spearman's correlation, *N*= 8

approach, and intensity. Contrary to predictions, there were no significant relationships found between the mothers' proportion of bell-shaped contours during the two toy conditions and the infants' TATA scores. However, some moderate to strong correlation coefficients did not reach significance (see table 1).

3.3 Slowly-falling contours and Infant Temperament

Slowly-falling contours, used to soothe fussy infants, were expected to be related to infant mood. In line with predictions, mothers did display more slowly-falling contours when their infant was rated as having a more negative mood in the 'toy' condition (r_s= .715, *N*= 8, *p*= .023), and 'no toy' condition (r_s= .695, *N*= 8, *p*= .028; see table 1).

3.4 Rapidly-falling contours and infant temperament

The mothers' proportion of rapidly-falling prohibitive contours were expected to be related to the infant's activity, mood, and approach levels. Contrary to predictions, there were no significant correlations between the proportion of rapidly-falling contours and mood, activity, and approach levels across both toy conditions. Again, some moderate to strong correlation coefficients did not reach significance (see table 1).

4. Discussion

The aim of the current study was to determine if infant temperament was associated with the proportion of rising, bell-shaped, slowly-falling, and rapidly-falling F_0 contours that the mother used during a mother-infant interaction.

4.1 Interpretation of Findings

The results of this study provide some support for a relationship between infant temperament and maternal F_0 contours. The negative associations between rising contours and the approach dimension of the temperamental assessment may indicate that mothers of infants with a low approach score attempt to increase her infant's attention. These findings are an extension of previous work that suggests rising contours attain infant attention and encourage participation [9, 29]. As low approach has been shown to relate to poorer attentional regulation in infants [35], it follows that infant approach was found to be related to attention-grabbing rising contours.

Infant mood was found to be related to the mother's contours, although differently than predicted. Contrary to predictions, there were no significant associations between rising and bell-shaped contours and infant mood. However, mothers did display more slowly-falling contours when the infants displayed a negative mood during the interaction. Slowly-falling contours are suggested to comfort upset infants, which one can equate with a negative mood. The present results suggest that an infant displaying temperamental characteristics of a negative mood would influence the mother to use F_0 contours to counteract negative affectivity [27, 28]. These findings provide a unique insight into the infant dimension of infant-mother communicative interaction, which for the most part has been investigated from the maternal dimension.

4.2 Limitations

We currently interpret the observed associations as reactions by the mothers to their infant's temperament. However, the associations could also indicate that the infants' temperament is a response to the mothers' use of F_0 contours. We find this alternative interpretation less likely, because F_0 contours are suggested to be a functional tool for mothers to use when interacting with their infants [10, 27].

The present study only took one measure of temperament for the entire interaction, and computed the overall proportion of each contour type. However, infant temperament may change over the course of the interaction [4]. These changes may either occur in reaction to the mother's use of contours, or elicit a change in contour use from the mother. A more fine-grained temporal analysis in future research will allow us to draw further conclusions about the direction of influence between mother and infant.

The current study took participants from the BLT-ID study in its early stages, and as such there were issues involving the methodology. One obvious issue was the sample size and subsequent diminished power. In terms of infant studies on F_0 contours, recent literature is based on studies with sample sizes anywhere between 10 to 80 participants [14, 19, 24, 31]. Our sample size falls below what is recommended in the published literature. Another issue was that the BLT-ID study is concerned with maternal asthma, thus all mothers who participated were asthmatic. This may have affected their IDS, however due to the time-constraints of the current study we were unable to test a control group. Lastly, there was no inter-rater reliability computed for either the TATA scores or the contour classification. Future studies should take these issues into consideration.

4.3 Significance, Implications and Conclusions

The findings of the current study indicate that infant temperament is linked to maternal IDS during a mother-infant interaction. Investigation into the potential contribution of infant characteristics to IDS is a relatively new subject [28, 31]. Studies that address the infant's influence on the mother can assist in the development of early interventions when the mother-infant relationship is at risk. Children who exhibit a particular temperament may be restricted to hearing a certain type of contour, and thus further research is needed to determine whether this has any long term developmental implications for the infant.

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