The Melody of Surprise: Maternal Surprise Vocalizations During Play with Her Infant

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Two groups of mothers and their infants (24 infants, mean age = 3.5 months and 24 infants, mean age = 5.5 months) were video- and audio-taped in their homes while playing with a Jack-in-the-box. The mean fundamental frequency of spontaneous surprise exclamations of mothers when opening the toy were analysed, and infant and maternal facial expressions of surprise were coded in three regions of the face. A t-test established that significantly more of the older children in comparison with younger children showed surprise (t = −2.96, df = 46, p < 0.005, 2-tailed). Twenty-nine per cent of the younger infants, in comparison with 67% of the older children showed facial expressions of surprise. A t-test of maternal pitch height (Hz) indicated that mothers exclaimed in surprise with a higher pitch when the child did not show a surprise facial expression (mean = 415.61Hz) in comparison with the child showing surprise (mean = 358.97Hz; t = 2.9, df = 46, p = 0.006, 2-tailed). A multiple regression established that infant’s expression was a stronger predictor of maternal vocal pitch than was the age of the infant. These results are discussed in terms of maternal use of emotional expressions as ‘social signals’. Copyright © 2002 John Wiley & Sons, Ltd.

Key words: maternal–infant interaction; emotional development; surprise; pitch

INTRODUCTION

In recent years there has been renewed interest in the development of emotion. However, one emotion to which relatively little research has been devoted is surprise. Many theorists distinguish between simple, primary of fundamental emotions and complex, secondary or derived emotions (e.g. Izard, 1977; Plutchik, 1980). Plutchik (1980) argued that surprise was a fundamental emotion, which could be observed alongside anger and joy at birth. Other theorists classify
surprise as a secondary emotion. They argue that the development of emotions has to be related not only to the social context in which the emotion is expressed (Fogel, 1993) but also the child’s cognitive maturity (e.g. Charlsworth and Kreutzer, 1973; Piaget, 1981; Zelazo, 1972). With regard to surprise, children have to learn the circumstances in which this emotion can be appropriately expressed (Camras, 1992). This learning occurs in the social context (Sroufe, 1996; Klinnert et al., 1983). Murphy (1983) argued that surprise, which he described as an ‘affectively toned cognitive response’ to a new event, can be observed at around 5 months.

Mothers finely tune their behavior to their infant’s reactions (e.g. Kaye, 1982; Papousek and Bornstein, 1992; Schaffer et al., 1977) and their vocal interactions are sensitive to their infants social-cognitive development. A number of developmental changes are recorded around 4–5 months of age (e.g. Camras, 1992; Muir et al., 1989; Murphy, 1983; Oster, 1981; Rheingold, 1966; Sroufe, 1996; Sroufe and Wunsch, 1972; Walker-Andrews, 1997). Trevarthen and Marwick (1986) pointed out that between 4 and 5 months of age infants undergo rapid developments in their perception and motor control, showing greater curiosity about external events. Around 4 months of age infants begin to reach and are spending less time gazing at their mothers than previously. This leads the mother to change her response to the infant’s vocal and behavioral actions.

Mothers use their voice as an instrument for socialization in general (Papousek, 1992; Reissland and Snow, 1996; Reissland, 2000) and emotional development in particular (Fernald, 1992). For example, with regard to referencing maternal emotional signals in ambiguous situations, Klinnert et al., (1983, p. 80) suggest that an infant ‘hearing a piercing scream from his mother’ will turn to look at her and then react accordingly. Although most studies on emotional development concentrate on facial expressions of emotions (Walker-Andrews, 1997), there is growing evidence that patterned information of the voice can specify affective information (Campos and Stenberg, 1981; Scherer, 1982a, b; Walker-Andrews, 1997).

The voice carries sufficient information to differentiate between various situations (Fernald, 1992; Reissland and Snow, 1996) and emotions (Scherer, 1982b, 1986). Scherer (1982b) reported that adults distinguish exclamations of surprise from vocalizations of other emotions such as anger, fear, shame or pleasure by auditory parameters. A high pitch level (measured in Hz) is strongly associated with surprise whereas a low pitch level is associated with pleasure (Scherer, 1982a). Although mean amplitude (measured in dB), is a measure commonly used in the acoustic analysis of speech (Scherer, 1982a, b) it is not significantly associated with surprise in comparison to other emotions.

Given the ability of mothers to fine-tune their behaviour, it is expected that mothers in the present study will adapt their vocal expressions of surprise to their infants’ ability to show surprise. It is expected that mothers will use a different pitch when expressing surprise depending on the facial expression shown by the infant, which should occur around the age of five months. Maternal vocal exclamations of surprise, such as ‘oh, ah, oops’, etc., directed at their infants will be compared in terms of mean fundamental frequency, loudness and length of the exclamation for infants at 3–4 months and 5–6 months of age. Similar exclamations used by mothers during a pleasurable play situation will be examined in order to establish a reference point for maternal child-directed pitch. Maternal and infant facial expressions will be coded for expression of surprise in three regions of the face. Additionally, infants’ and maternal gazing patterns will be analysed. The aim of the paper is to establish whether mothers adjust the pitch of their voice depending on their infants’ expression of surprise in a surprise-eliciting situation.
METHOD

Participants

Two groups of Scottish mothers and their infants (24 infants, mean age = 3.5 months, range 3–4 months, 12 males, 12 females and 24 older infants, mean age = 5.5 months, range 5–6 months, 12 males, 12 females) took part in the experiment. The mothers were monolingual English speakers and were primary caregivers. Mothers had a mean number of 14.7 years of education, ranging from 10 to 20 years.

Procedure

The children and their mothers were observed in their own homes while playing with a Jack-in-the-box placed between mother and child. Two video cameras were used, one focusing mainly on the mother and the other focusing mainly on the child. The Jack-in-the-box play was part of a larger study on mother–infant interaction, in which mothers played with a soft toy and read a picture book to their infants. Infants sat in a baby-chair or propped up with a pillow. Mothers were instructed to play with the soft toy and open the Jack-in-the-box as they normally would. They were not told how to play with the soft toy or to express surprise while playing with the Jack-in-the-box. The spontaneous vocal expressions of the mother when opening the Jack-in-the-box and playing with the soft toy were tape-recorded.

Acoustic measurements

All vocalizations selected for analysis were digitized using Signalize (Keller, 1994). The pitch extraction algorithm reported fundamental frequency values ($F_0$) for each 5ms of voiced speech. For each utterance, the following measures were obtained: minimum, maximum, and mean $F_0$ values, measured in Hz. The amplitude was measured by a pitch-synchronous energy calculation. Minimum, maximum and mean amplitude, measured in dB was obtained for each utterance. The length of each utterance was measured in seconds.

The vocal exclamations of surprise (e.g. oh, ah or oops, etc.) immediately following the opening of the lid of the Jack-in-the-box were recorded. All mothers vocalized their surprise at some time during the interaction. The vocal surprise exclamations of the mothers varied in length from 0.13s to 1.18s, mean 0.42s. Only voiced vocalizations, which were free from excessive background noise or overlapping speech, were analysed. Furthermore, maternal vocalizations of ‘oh’ and in one case ‘one’ during their play with the soft toy were recorded and analysed in order to provide comparable vocalizations, which represent a baseline for surprise vocalizations.

Maternal and Infant Facial Expression

The occurrence or non-occurrence of component facial expressions of surprise was coded from three regions of the face, based on the coding scheme described by Hiatt et al. (1979). The three facial regions are: (1) eyebrow, forehead, (2) eyes, lids and (3) nose, mouth regions. Two of three regions of the face have to show components of surprise, in order for the facial expression to be labelled surprise. The components present in a surprise face are: for the eyebrow, forehead region, any one or more of the following, (a) the brows are raised so that they are curved and high, (b) horizontal wrinkles go across the forehead and (c) the skin below the brow is stretched. These codes correspond to AC20 in the MAX coding.
system (Izard, 1995). For the eyes/lids region the component for surprise is present when the eyelids are opened; the upper lid is raised and the lower lid is drawn down. This code corresponds to AC30 in the MAX coding system (Izard, 1995). For the mouth–nose region, the component expressing surprise is when the jaw drops open so the lips and teeth are parted, but here is no tension or stretching of the mouth. This code corresponds to AC50 in the MAX coding system (Izard, 1995). Mother and child were credited with not showing surprise (= 0) or with showing surprise elements in 1, 2 or 3 regions of the face.

**Reliability**

The observational data were re-coded by an independent observer, blind to the hypothesis. Agreement was scored if the coders agreed on the movement coded in each of the three regions of the face. Reliability of the data was calculated for 12.5% of the infants (6 out of 48 infants) and for 12.5% of the mothers (6 out of 48). For the infants, reliability ranged from 80.8% to 100% agreement, with a mean of 94.75% agreement. For the mothers, reliability ranged from 76.9% to 100% agreement, with a mean of 94.21% agreement.

**RESULTS**

**Vocal Aspects of Surprise Exclamations**

A sign test established that 46 out of 48 mothers used a lower pitch when vocalizing ‘oh’ during the pleasurable situation in comparison with the surprise-eliciting situation ($Z = 6.2, p < 0.0001$). A paired $t$-test established that the pitch during pleasure vocalizations was significantly lower (mean = 239.20Hz) when vocalizing ‘oh’ in comparison with their exclamations during the surprise-eliciting situation (mean = 388.47Hz; $t = 11.35, df = 47, p = 0.000, 2$-tailed).

$T$-tests of age-group of child (younger group, older group) were computed for the mean fundamental frequency (Hz) of maternal surprise exclamations, for the amplitude of her exclamations (dB), as well as the length of her exclamations (seconds). The mean fundamental frequency of the surprise exclamations resulted in a significant effect of age ($t = 2.56, df = 46, p < 0.01, 2$-tailed). Mothers of mean age 3.5 months old infants used a significantly higher mean fundamental frequency (mean = 413.96Hz) in comparison with mothers of mean age 5.5 months old children (mean = 362.99Hz) when exclaiming in surprise. There was no difference in the length ($t = 0.114, df = 45, p = 0.91, 2$-tailed, ns) or amplitude ($t = -0.148, df = 45, p = 0.88, 2$-tailed, ns) of surprise exclamations.

**Facial Expressions of Surprise by Mother**

A $t$-test of age-group (younger group, older group) was computed for maternal facial expression of surprise across three regions of the face. The codes ranged from not showing surprise (= 0) to showing surprise in 1, 2 or 3 regions of the face. There was no significant effect of age of child for mother’s expression of surprise ($t = -1.31, df = 45, p = 0.195, 2$-tailed, ns). Mothers of the mean age 3.5 months old infants showed the same amount of surprise (mean = 2.17 regions of the face) compared with 5.5 months old infants (mean = 2.54 regions of the face).

**Facial Expressions of Surprise by Child**

A $t$-test of age-group of child (younger group, older group) was computed for three regions of the face for the child. The codes ranged from not showing surprise (= 0) to showing surprise in 1,2, or 3 regions of the face. There was a
significant effect for age of infant \((t = -2.96, \text{df} = 46, p = 0.005, \text{2-tailed})\). Younger infants showed significantly less surprise (mean surprise = 0.79 regions of the face) in comparison with older infants (mean surprise = 1.70 regions of the face). Using the criterion for surprise that two or more regions showed the appropriate components, 29% of younger infants showed surprise compared with 67% of older infants.

**Maternal Voice Pitch and Child’s Facial Expression**

To test whether the pitch of the mother’s voice was contingent on the child’s facial expression, infants’ facial expressions were classified as either showing surprise or not showing surprise. A \(t\)-test comparing the mean maternal voice pitch of children showing surprise (mean = 358.97Hz) or not showing surprise (mean = 415.61Hz) irrespective of age was significant \((t = 2.9, \text{df} = 46, p = 0.006, \text{2-tailed})\). However, mothers of younger babies also spoke with a higher pitch (mean = 413.61Hz) in comparison with mother of the older babies (mean = 362.99Hz, \(t = 2.56, \text{df} = 46, p = 0.01, \text{2-tailed})\). In order to identify the relative contributions of age and surprise expressions to pitch level (Hz), a multiple regression was run with age of infant and measure of surprise (0–3 regions of the face) as the predictor variables and pitch level (Hz) as the dependent variable. The multiple correlation coefficient was highly significant \((R = 0.482, p = 0.003)\). Examination of the Beta coefficients showed that infant’s surprise expression (beta = −0.407) was a stronger predictor of pitch level than the age of the child (beta = −0.126). It therefore appears that it is the expression of the child which is more critical in determining the mother’s vocalization than the child’s age.

**Direction of Gaze by Mother and Child**

In an attempt to identify the source of referencing during vocal and facial expressions of surprise, the numbers of mothers and infants looking at the partner were compared. During the period in which mothers were exclaiming in surprise, 90% of mothers were looking at their infant compared with 40 per cent of infants looking at their mother. A Sign test was significant \((Z = -4.23, p = 0.000, \text{2-tailed})\). Hence, significantly more mothers look at their infant’s facial expressions than infants looking at their mothers’ facial expression.

**DISCUSSION**

The findings of this paper indicate that mothers of the younger babies in comparison with mothers of older babies used a higher mean pitch in their surprise exclamations. Furthermore, 70% of the younger infants did not show surprise facial expressions. In contrast 67% of older infants did show surprise. Significantly, more mothers looked at their infant’s face (90%) compared with infants looking at their mother’s face (40%). Although three to four months old infants are able to visually discriminate between emotions (LaBarbera \textit{et al.}, 1976; Young-Browne \textit{et al.}, 1977) and facial expressions of surprise have been identified already in 4-month-old infants (Izard \textit{et al.}, 1980), very young infants expression of ‘surprise’ may be an artefact of the way toys are presented to them rather than facial expressions of surprise-reactions (Camras \textit{et al.}, 1996). Camras \textit{et al.} (1996, p. 186) write: ... ‘the infants’ “surprise” expressions were not produced in situations that were likely to have elicited surprise’.
In some contexts, emotional expressions are used as ‘social signals’, in order to influence the behaviour of others (Campos et al., 1994). The present findings suggest such a context. Mothers of younger infants used high pitched vocal expressions of surprise. Furthermore, virtually all mothers looked at their infant when expressing surprise, but only a minority of infants looked at their mothers. Hence, it seems that while monitoring their infants’ facial expressions, mothers exaggerate or alternate their vocal expression of surprise.

The development of emotion cannot be separated from its social context (Fogel, 1993). If emotions evolved according to a pre-determined time-table, then one would expect a mother to adjust her emotional expressions, both vocal and facial expressions, according to the age of her child. If, however, mothers monitor their child’s level of competence, then one would expect the mother to adjust the emotional expression according to the child’s emotional expressions in the specific social context of interaction. The results of the present study showed that mothers fine-tuned their reactions to the individual infant’s facial expressions. Mothers of babies who did not show surprise, vocalized their surprise with a higher pitch than mothers of babies who did show surprise.

Social communication is learned and parents provide the behaviours which allow an infant from birth to interact with them as partners (Kaye, 1982). It is the parent who provides frameworks for the infant (Kaye, 1982; Reissland, 1990). This interaction between parent and child is rarely silent. Rather, mothers provide a running commentary on everything they do, including labelling the infant’s emotional expression. It is possible that, as Malatesta and Haviland (1982) argue, observation of facial expressions is a method of learning between 3 and 6 months. The results of present study, however, suggest that it is the mother who adjusts her vocal behaviour according to infant facial expressions rather than infants referencing the facial expression from their mother’s facial display of surprise.

In conclusion, mothers use vocal expressions of surprise as ‘social signals’ which vary with the emotional expression of the child. They do not, however, vary their own facial expressions of surprise according to either their infant’s age or emotional reactions. How do children learn emotional expressions in the appropriate context? The present study indicates that infants between 3 and 6 months of age do not learn emotional expressions by referencing their own facial expression from the facial expression of the mother. Rather it is suggested that mothers modulate their vocal expressions depending on the facial expression of their infant and hence these young infants might learn by listening to their mother’s voice rather than by looking at her face.

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