Paper II

Prosodic modification and vocal adjustments in mothers' speech during face-to-face interaction with their 2-and 3- month old infants: A Double Video study

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Acknowledgements: The authors would like to express their gratitude to Lisa Gustavsson for her assistance in analysing the audio data

Abstract

The purpose of this study was to examine mothers' sensitivity to social contingency during face-to-face interaction with their 2-3 month old infants in a closed circuit TV set-up. Prosodic qualities (mean fundamental frequencies (F0), Percentage amount of F0 speech) and mean vocal production in mothers' Infant Directed (ID) speech to their 2- 3 month-olds during sequences of live interaction were compared to sequences where the mother-infant interaction was set out of phase by presenting either the mothers (Replay2) or the infants (Replay1) with a replay of the partners' former behaviour in a Live1-Replay1-Live2-Replay2-Live3 design. The mothers' evidenced overall significantly higher amount of ID speech during the live compared to the replay sequences. Compared to the amount of ID speech during the Live1 sequence, mothers evidenced a significant reduction in ID speech during both replay sequences. However, the mothers only evidenced a recovery in ID speech from the Replay2 sequence, not the Replay1 sequence, even though there was no significant difference between the two replay sequences. These findings suggest that prosodic qualities of mothers' ID speech are modulated by social contingency in the infant-mother interaction.
Keywords: Social contingency; Mother-infant communication; Infant Directed speech; Prosodic modification

Introduction

The prosodic modification that is expressed in Infant Directed speech (ID) refers to the prosodic exaggeration (Panneton Cooper, Abraham, Berman & Staska, 1997) and music-like tone (Fernald, 1992) found in parents when communicating with their infant. ID speech differs from Adult Directed (AD) speech in intonational features where ID shows significantly higher mean fundamental frequency (F0) (Panneton Cooper et al., 1997), greater pitch variability and shorter sentences with longer pauses (Fernald & Simon, 1984) than AD speech.

ID speech serve several purposes (Bornstein, 1996); the prosodic features act as pre-potent signal in eliciting and maintaining the infants' attention, and modulate arousal (Panneton Cooper & Aslin, 1990), and provide the infant with information about the parents' affective state (Fernald & Simon, 1984), but also increase the affective responsiveness of the infant. ID speech is adjusted to the infants' limited capacities in perceiving and processing information (Papoušek, Papoušek & Bornstein, 1985), but also enhance these abilities through the infant's perception of the multimodal components of auditory, visual and motor information from the caregivers vocalisation (Kuhl, 1998). It is therefore suggested that ID speech function to facilitate the emotional relationship between parent and adult (Werker & McLeod, 1989).

Trainor, Austin and Desjardins (2000) found in their research that the differences between ID speech prosody relative to AD speech

prosody are qualified by the free expression of emotions in ID speech. If the expression of emotions is more restricted when adults talk to other adults, it is suggested that the information communicated to infants is mainly emotional (see Trainor et al., 2000). This seems to be especially relevant in communication with small infants that not yet produce words. Since content of the caregivers speech might be less important (see Panneton Cooper & Aslin, 1989), the great use of prosodic features in caregivers vocalisation when talking to their young infants (Stern, Spieker, Barnett & MacKain, 1983) seems to be more informative.

Emotional communication in early caregiver- infant interaction is also highlighted in Trevarthen's (1980) theory of intersubjectivity. Intersubjectivity is postulated as a shared understanding between caregivers and infants that is exclusively devoted to the reciprocal exchanges of emotional information between the caregiver and the infant. Infants active contributions in face-to-face interactions are explained as innate motives for communication (Trevarthen, 2001) that ca be observed in the infants timing and emotional tone during the interaction (Trevarthen, 1980).

The questions of interest in this study are two-fold: The growing literature on ID speech suggests that prosodic- and vocal modification of speech during conversation with infants is a global phenomenon. It is however also acknowledged that the prosody in ID speech is dependent on the quality of the feedback from the infant to elicit and shape the full range of prosodic modification (see Fernald & Simon,

1984). Thus, even if ID speech is a normal way of talking to infants, it is suggested that this is not a speech style that is independent of the infants' behaviour and emotional state.

The Double Video procedure, first presented by Murray and Trevarthen (1985), represent a perturbation paradigm that was developed to assess the capacity of sensitivity to social contingency in young infants. Infants and their mothers can communicate by seeing and hearing another's facial expression and hear one another's vocalisation live or in a sequence where the interaction is set out of phase by presenting the infant or the mother with a televised replay of the companion's previous behaviour (see Murray & Trevarthen, 1985; 1986). In their classic report, Murray and Trevarthen (1985) found that their sample of four infants (6-12 weeks of age) evidenced a decline in gaze and positive affect during a televised replay of their mothers' behaviour compared to the preceding sequence when they interacted in a televised live interaction. More recently, Nadel, Charchon, Kervella, Marcelli & Réserbat-Plantey (1999) and we (Stormark & Braarud, 2004; Braarud & Stormark, in print) evidenced the same phenomena, and even more importantly, found that the infant is capable to re-engage in mutual interaction after one (Nadel et al., 1999) and two replay sequences (Stormark & Braarud, 2004; Braarud & Stormark, in print).

While a number of Double Video studies (see Hains & Muir, 1996; Bigelow, MacLean & MacDonald, 1996; Rochat, Neisser & Marian, 1998; Nadel et al., 1999; Legerstee & Varghese, 2001) have

examined infants' sensitivity to social contingency, only Murray and Trevarthen (1986) and we (Stormark & Braarud, 2004) have investigated mothers' sensitivity to social contingency in an attempt to further address question about the infants social contribution to early face-to-face dialog with the caregiver. For example, what looks like a two-way dialog can simply reflect the mothers' sensitivity to the pauses between the infant's irregular behaviour, where the mother adjusts herself to the infant's responses and pauses, and thus makes it look like a mutual interaction. If this was the case, maternal responses during live interaction with their infants should not be any different from what could be observed when they witness a video-recording of their infants' behaviour from a comparable sequence of interaction.

Murray and Trevarthen (1986) found differences in both content and stylistic features of maternal speech during live, real-time interaction between mothers and infants compared to when the interaction were set out of phase by presenting the mother with a replay of the infant. The main findings were that the mothers' verbal responses consisted of more genuine questions, shorter mean length of utterances and more complete repetitions in two Live sequences compared to more directives, prompt questions, call for attention, correction and negative statement during two Replay sequences. More recently, Stormark and Braarud (2004) found that the mothers looked significantly more at their infants during a following live sequence after they were presented with a replay (in Replay2) of their infants' previous behaviour, but not when the interaction was set out of phase

by presenting a replay of the mothers behaviour to the infant while the infant saw the infant live (in Replay1). The results also showed that the mothers looked nearly 100 percent at their infants during the experiment, with only a small percent of variation. This lack of variation between the contingent and non contingent sequences could suggest that the assessment of amount of gaze at the infant does not give insight into the signal value of the caregivers' gaze focus (see also Emery, 2000). For example, even if gaze is an important component of social interaction, there is a different motivation behind caregivers' intense gaze at their infant during intimate intersubjective sharing compared to intense gaze focus that is expressed in an attempt to receive attention from their infant. In sum, the findings from earlier Double Video studies (see Murray & Trevarthen, 1986; Stormark & Braarud, 2004) suggest that ID speech is a more valid variable than mothers gaze foci.

Murray and Trevarthen (1986) observed and analysed the content, syntactical form and complexity of the mothers' vocalisation. However, while semantic and syntactic features remain relatively stable over the first 18 month (Snow, 1977), the prosodic organisation is dynamically responsive to age-related behaviour changes during the first year (Stern et al., 1983).

The purpose of the study is to investigate prosodic and vocal modification in mothers ID speech when social contingency is manipulated during face-to-face interaction with their young infants, in a Double Video experiment and explore if ID speech is a function

of the quality of the infants' responsiveness. To investigate this, phonetic acoustic correlates of prosody (see Price & Ostendorf, 1996) including mean fundamental frequency (F0) and the relative amount of time with registered F0 speech was chosen as dependent variables', together with the amount of produced vocal sound. The experimental set-up included five sequences, three live and two replay sequences in a Live1–Replay1-Live2-Replay2-Live3 order. The manipulation of social contingency lead to a de-synchronisation of the communication, which Gianino and Tronick (1988) defines as interactive distress. Given that the prosody in ID speech is dependent on the quality of the feedback from the infant to elicit and shape the full range of prosodic modification (see Fernald & Simon, 1984), it was expected that the there would be an increase in mean F0, and more F0 speech during the Live sequences compared to the Replay sequences. Elsewhere, Field (2002) found decreased vocal production by mothers talking to their infants during distressing context compared to normal context. It was therefore expected that the non-contingent sequences would cause less amount of vocal production compared to the contingent sequences.

Method

Subjects

32 mothers (mean age: 29 years, range 20-39) and their infants with a mean age of 11 weeks and 3 days (range 6-17 weeks) participated in the study. 30 mothers were married or co-habitants and 2 were single mothers. Socioeconomic status was assessed in relation

to educational level: Ten had earned a master degree, 11 a bachelor degree, and 11 had graduation from high school as their highest level of completed education. The mothers were recruited to the study by the nurses at the health care centre of the mothers and their families' residence. The nurses distributed information about the project with an informed consent at a home visit during the first weeks after delivery or at the first Well Baby visit at the health care centre. The study was a part of a larger longitudinal project on infant emotional development (see also Braarud & Stormark, 2006). The mothers gave their informed consent to participation directly to the researcher. Some weeks before the infants reached 2 months of age, they were approached by the researcher and asked to come to the laboratory where the experiment took place.

Apparatus

Figure 1 shows the experimental set-up. During the experiment the interaction took place through a closed circuit TV system which retain a life size full-face image and voice of the partner and enabled direct eye contact. The mother and the infant were placed inside three-sided booths where the inside-walls were isolated with foam rubber plates to ensure optimal audio quality, in two separate sound and light-proof rooms. One-way mirrors were arranged diagonally inside the booths in a distance of approximately 50 cm from both the mother and the infant. The mirrors reflected the screen of a 14" TV monitors that were placed on the top of each booth, facing down towards the

mirrors. A Sony CCX-ZIIE digital colour video camera connected to a Pinnacle Miro DC 30+ video card and AKG D230 microphones (direction sensitive) connected to a PC via an amplifier were placed behind the one-way mirror. To reduce the risk that TV-speakers in the mother's booth would pick up her voice from the microphone in the infants' room, the mother received the audio-input from her infant through ear-plugs.

Insert figure 1 about here

A local PC network transmitted audio- and video signals from one partner to the other's TV-monitor. The network consisted of three PCs equipped with the Microsoft Transaction Server software to synchronise the transmission and recording of the signals in the different sequences of the experiment. Audio- and video signals from the mother and the infant were recorded and stored separately on PC 1 and PC 2 equipped with Pinnacle System Miro version DC 30+ video card in all five experimental sequences. The video files depicting the behaviour of the mother and the infant during the first live interaction sequence (Live 1) were copied from PC 1 and PC 2, and stored in PC 3, equipped with Pinnacle Systems Miro DC10 video card which controlled the playback of the mother's and infant's behaviour from Live 1 sequences during Replay 1 or Replay 2. The experiment consisted of five interaction sequences, Live1-Replay1-Live2-Replay2-Live3, each with a duration of 30 seconds, with a seamless

shift between the sequences. To make sure that the mothers and their infant were able to establish contingent face-to-face interaction, all the subjects started with a live- sequence. Also, to reduce the possibility that the mothers would remember the infants' behaviour responses in the first live sequences, all the mothers' received the video-recording of their infants during Replay 2. Thus, the Replay sequences depicted a replay of the mother's vocalisation to the infant from Live 1 during Replay 1, and the mothers' received a video-recording depicting their infants' behavioural responses during Live1, in Replay2. See also Stormark and Braarud (2004) for further details.

Procedure

In the laboratory the mother was explained that the purpose of the study was to investigate mother-infant interaction using a closed circuit TV system. The mother was told that the experiment included several sequences, but she was not informed about the shift between Live- and Replay conditions. When the mother and the infant had adjusted to the laboratory setting, they were seated inside each of the booths so they could see and hear each other through the closed circuit TV system. The mothers were asked to try to establish contact with their infants via the TV-monitors. This took approximately 2-3 minutes. When the experimenter, who saw real time images of the mothers and the infants on separate monitors, judged that the partners had established contact, the experiment started.

Data scoring

All the video recordings were transformed from avi to mpg format. All vocal productions by the mother were transcribed by three coders, who were blind to which sequences contained live or replay interaction. The amount of vocal production was added up and constituted a dependent variable called vocal sounds. Interrater agreement between the three coders was calculated for five of the transcripts, comprising an interrater agreement of 100%.

In order to prepare the files for acoustic analysis, the mpg-files was transformed to Wav-files using VirtualDub 1.5.4 (VirtualDub, 2006). Then the audio files were filtered for background noise forward and in reversed direction using Adobe Audition (Adobe Magazine, 1998). All vocalisation were digitised using SoundSwell 4.0. (see Hightech Development, 2006) and the pitch extraction algorithm gave a F0 for each 3.6 msec of voice production. The mean F0 was obtained for all utterances in each sequence. Also, amount of time with F0 vocalisation was estimated as a relative score, based on percentage of F0 vocalisation in each sequence.

Design and statistical analysis

Descriptive data of mean F0 vocalisations, mean duration of F0 vocalisations and mean amount of vocal sounds are shown in Figure 2. The three dependent variables are considered to be different correlates of ID speech and were summed under the heading “ID speech”. Then the dependent variables were subjected to repeated measures of

MANOVA comprising Sequence (Live1, Replay1, Live2, Replay2, Live3). To investigate if changes in ID speech between the live and replay sequences were specific to the experimental manipulations, live sequences had to be presented both before and after the replay sequences. Thus, since the number of live sequences had to exceed the number of replay sequences in this experiment, the dataset was examined in a priori comparisons (planned comparisons of contrast variables: Hays, 1988), so that the live and replay sequences could be weighted equally.

Insert figure 2 about here

The age range of the infant sample was considerable. Given that caregivers' prosodic organisation is dynamically responsive to the infants' age related behaviour changes (Stern et al., 1983), a linear regression analysis was conducted to control for that the results were not qualified by the infants' age. The infants' age was the predictor variable whereas the dependent variable was a differentiation measure of the mean F0 of the mothers' prosodic modification in the replay sequences subtracted from the mean F0 in the live sequences.

Results

There was a significant main effect of mothers ID speech ($F(3, 29) = 4.94$, $p < .01$), reflecting that the mothers evidenced significantly more ID speech during the Live than the Replay sequences (see Figure

2). Further, there was a significant higher amount of ID speech in Live1 compared to Replay1 ($F(3, 29)= 3.21$, $p< .05$) and compared to Replay2 ($F(3, 29)= 7.73$, $p< .001$).

To address the question of possible carry-over or recovery effects, ID speech between each individual sequences were analyzed. There were significant differences between each of the subsequent sequences, with one exception; there was no recovery from the Replay1 to the Live2 sequence. Apart from this the analyses evidenced a significant reduction in ID speech from Live2 to Replay 2 ($F (3, 29) = 2.92$, $p<.05$) with a significant increase in ID speech from Replay2 to Live3 ($F (3, 29) = 4. 95$, $p< .01$) which reflects that the only carry over effect was found from Replay1 to Live 2 ($F (3, 29) = 1.30$, $p= .29$). There was no significant difference between amounts of ID speech in the two Replay sequences, and there were no significant differences between amount of ID speech during Live2 compared to both the Live1 and the Live3 sequence.

A linear regression analysis was conducted to examined if the differentiation between live and replay sequences that was found in the mothers' prosody was qualified by the infants age, but the result did no evidence for an age effect.

Discussion

To sum up the results; there was a higher amount of ID speech in terms of amount of mean F0, F0 production and number of vocal sounds during sequences of live, real-time interaction compared to the

sequences were the interaction between the mother and the infant was set out of phase. This was substantiated by significant differences in ID speech between Live1 and Replay1, and between Live1 and Replay2, with a significantly lower amount of ID speech in both replay sequences compared to the Live1 sequence. In accordance with this, there were significant differences in ID speech between each of the sequences, except for a non-significant increase from Replay1 to Live2.

The differences in ID speech between the Live and the Replay sequences suggest that the mothers were affected by the subtle sensory, yet important experiential differences between live and replay sequences. It is difficult to attribute this to fatigue or any other factors related to the lapse of time, since level of maternal ID speech remained at the same level during the last compared to the first live sequence the experiment. The decline in the mothers' ID speech during Replay2 could be attributed to a memory effect, since the perturbation of the mother-infant interaction in this sequence involved that the mothers saw a replay of the first live interaction with the infant. However this can not account for the equally pronounced decline during Replay1, where the mothers saw the infant live. Nevertheless, there was not an equal recovery effect in maternal ID speech after the perturbation of the Replay1 as was shown from Replay2 to Live3. In accordance with Gianino and Tronick (1988) one could argue that the mothers did not manage to establish a

successful repair after the mismatch in communication during the non-contingent interaction during Replay1.

Our finding is in fact corresponding with the finding on maternal gaze at infant in Stormark and Braarud (2004) study, where there were no decline in maternal gaze during Replay1 compared to the preceding and subsequent sequences of live interaction, while Replay2 involved a significant decline compared to the subsequent Live3 and a non-significant decline compared to the preceding Live2 sequence. Nevertheless, the results from the two studies depart in the significant decrease ID speech from Live1 to Replay1, and tendency for an increase from in ID speech from Replay1 to Live2 (see also Figure 2) that was found in this study. This Live1-Replay1-Live2 variation was not found in our first study (see Stormark & Braarud, 2004).

One explanation of the result is that it is mainly the mothers who guide early face-to-face interaction. Support for this was found in our (Stormark & Braarud, 2004) previous study where the infants showed significant difference in gaze preference during live and replay sequences, while the mothers evidenced a high amount of looking at their infants in all five sequences. This could mean that the mothers are highly attentive to their infants, but still, as the results from mothers ID speech shows, the mothers recognize the lack of contingency in the replay sequences.

These results suggest that the experimental manipulation of social contingency provoke distinct responses in the mothers ID

speech and that mothers ID speech is driven by the quality of the infants' responses. It is possible that the length of each sequence is just within the limit to evidence sensitivity to contingency in accordance with the dependent variables used in our study. One could suspect that even if the mothers recognize that they are in mutual contact (Live2) with their infant after a non contingent sequence, the latency in readjusting the prosody in their vocalisation last longer than 30 seconds. An extension of each sequence in future research could give a stronger confirmation of the mothers' sensitivity to different qualities of the infants' behaviour responses.

The results accord with Murray and Trevarthen's (1986) findings that mothers ID speech adapts to the contingent qualities of the infants' responses. However, Murray and Trevarthen (1986) explored the content and stylistic features of the mothers' utterances and compared them as separate parameters in live and replay condition. In this study, we explored different correlates of the prosodic organisation and vocal production of mothers' vocalisation to their 2-3 month olds. Since all the three dependent variables showed the same pattern of response distribution over the sequences, MANOVA was chosen as the most appropriate statistical analysis.

The fact that the mothers' evidenced changes in relation to the experimental manipulation suggest that early face-to-face communication is dependent on contingent responses from the infants, and then support the idea that infants play an active communicative role in early face-to-face interaction.

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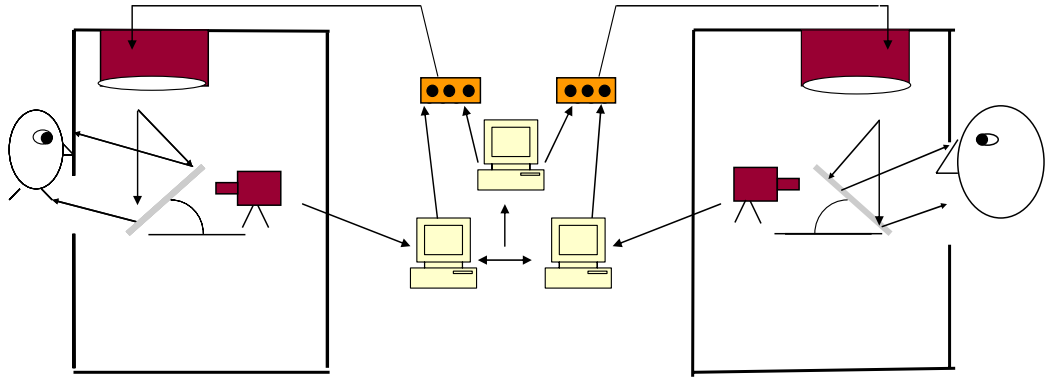
Figure caption

Figure 1. Schematic outline of the experimental setup. Both audio and video outputs from the mothers and the infant were recorded through microphones and video-cameras positioned behind the one-way mirrors and stored on separate PCs connected in a network. During the live sequence, the output from the mother and the infant was sent to the companion, using loop-through function. Prior to the replay sequences, the audio and the video output from the images recorded during Live1, from the infant and the mothers, respectively, was transferred from PC1 and PC2 to PC3, where the output from the mother was replayed to the infant during Replay1 (mother saw infant live) and to the mother during Replay2 (the infant saw mother live).

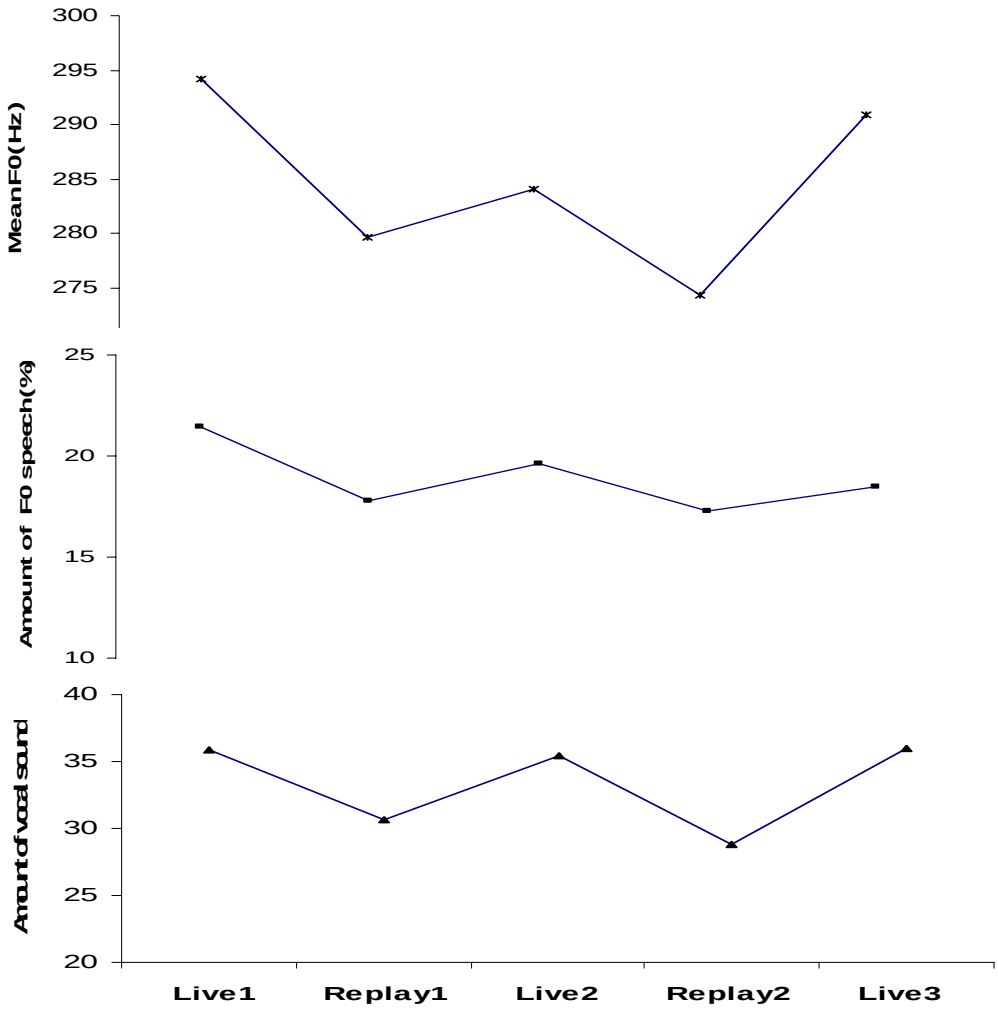
Figure2. Three linear graphs of observed mean in each single dependent variable, vocal sounds, percentage amount of time with F0 vocalisation and mean F0, during Live1-Replay1-Live2-Replay 2-Live3

Figure 1.



Live 1	Infant sees partner live	Partner sees infant live
Replay1	Infant sees a replay of partner's previous behavior	Partner sees infant live
Live 2	Infant sees partner live	Parner sees infant live
Replay 2	Infant sees partner live	Partner sees a replay of infant's previous behavior
Live 3	Infant sees partner live	Parner sees infant live

Figure 2.



×--- × Mean F0 (Hz)

■---■ Percentage amount of F0 speech

▲---▲ Amount of vocal sounds