

Early sensitivity to interpersonal timing

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Abstract

Sensitivity to timing in interaction was assessed in mother-infant interaction. In Study 1, three-month-old infants were presented with an image of their mother interacting with them on television, which was either live or temporally delayed by 1 second. Infants detected the temporal delay and were more attentive when the mother was presented live compared to delayed by 1 second. In Study 2, mothers interacted with an image of their three-month-old infant, which was either live or temporally delayed by 1 second. Mothers did not respond to a 1-second delay in their infants' behavior. In Study 3 and 4, the results were replicated with six-month-old infants.

1. Introduction

Interpersonal timing is a crucial aspect of human communication and intersubjectivity. Temporal coordination of behavior, i.e., changes in the timing of one individual's behavior in relation to timing of another's behavior, has been called the "bedrock of all social interaction" (Crown, Feldstein, Jasnow, Beebe, & Jaffe, 2002).

In early caregiver-infant interactions interpersonal timing is likely essential for mutual attunement (Rochat & Striano, 1999). Parental responses generally occur within 1-2 seconds after the infants' behavior (e.g., Keller, Lohaus, Völker, Cappenberg, & Chasiotis, 1999). Interestingly, this timing falls within the 3-second time interval that infants require to detect a contingent relation between their own actions and an outcome (Watson, 1967).

Temporal contingency is likely an independent component of parenting behavior, i.e., promptness of maternal behavior is not associated with warmth and affection (Keller et al., 1999). However, in prior research on infant sensitivity to social contingencies in interaction, timing of responses has never been assessed alone (e.g., Murray & Trevarthen,

1985; Nadel, Carchon, Kervella, Marcelli, & Réserbat-Plantey, 1999).

In the present series of studies, therefore, we assessed three- and six-month-old infants' and caregivers' sensitivity to interpersonal timing by using a new paradigm, in which only the timing of responses was manipulated¹.

2. Method

A double closed-circuit color monitor system was built similar to that used by Murray and Trevarthen (1985). Mothers and infants interacted over a double video system in real time and temporal delays of 1 second were implemented within the on-going interaction. The caregiver's image was transmitted to the infants' monitor and vice versa. A steel frame supported a TV monitor facing down. The image was reflected onto a one-way mirror, positioned diagonally in the steel frame and reflecting the partner's video image at eye level. Digital video cameras filming the interaction were positioned at eye level behind the mirrors so as to enable eye contact. The 4-minute interaction was separated into two 2-minute seamless segments. For 2 minutes the dyad interacted in real time (Live condition), and for 2 minutes the image and voice of one partner was temporally delayed (Delay condition). Conditions were counterbalanced. The audio delay was consistent with the image in the delay condition. In Study 1 and 3, three- and six-month-old infants interacted with an image of their caregiver, which was live or delayed by 1 second ($Ns = 34$ and 29 respectively). In Study 2 and 4, caregivers interacted with an image of their 3- or 6-month-old infant, which was live or delayed by 1 second ($Ns = 33$ and 26 respectively).

3. Results and Discussion

The amount of time the partners gazed, smiled and vocalized to each other was coded. General Linear Mixed

¹The presented data is currently submitted for publication (Striano, Henning, & Stahl).

Model analyses were applied to assess whether infants' behavior (Study 1 and 3) varied in relation to the timing of maternal responses, independent of maternal behavior. Similarly, in Study 2 and 4, we assessed whether mother's behavior varied in relation to the timing of infant responses, independent of infant behavior. Infant gender and order of conditions did not yield any significant main effect in any of the GLMMs performed.

When controlling for maternal behavior, infant gazing significantly differed as a function of condition, both at three months, $F(1, 34.3) = 5.08, p = .031$, and at six months: $F(1, 27.0) = 4.38, p = .046$ (Study 1 and 3). Infants were reliably more attentive to their mothers' image when she was interacting live compared to when she was delayed by 1 second (Live: $M = 57.9\%$; Delay: $M = 41.9\%$). These findings suggest that infants were sensitive to the 1-second delay implemented in the face-to-face interaction during the delay condition.

When controlling for infant behavior, at both ages, maternal behavior did not differ between conditions, $ps > .08$ (Study 2 and 4). These results suggest that mothers adjusted to their infants' behavior without being perturbed by its temporal delay. This explanation is supported by several significant relations found between infant and maternal behaviors that point to a mutual attunement between mother and infant (e.g., Stern, 1985).

Whereas 3- and 6-month-olds were more attentive when mothers were presented live compared to delayed by 1 second, at both ages infant smiling and vocalizing did not differ between conditions, $ps > .16$. Given that only the timing of maternal responses was manipulated while maintaining all other aspects of contingency, it is likely that this 1-second delay did not influence affective attunement between the dyad (Stern, 1985). Several significant relations found between infant and maternal behavior support this explanation.

These results support and extend prior findings of Murray and Trevarthen (1985) and Nadel et al. (1999)², suggesting that by three months of age infants are not only sensitive to overall interpersonal contingency but also to the timing of social interaction. Our findings further suggest that while infants are sensitive to changes in interpersonal timing, mothers provide prompt responses (e.g. Keller et al., 1999) and adjust to temporal delays in infant behavior

In addition to establishing a sense of reciprocity, timing may provide cues about the referential aspects of communicative signals that are essential in understanding others' intentions (Baldwin, 1993; Tomasello, 1999). Timing might thus be an integral part of the detection of intentional relations associated with the detection of human agency (Johnson, Booth, & O'Hearn, 2001), language (Clark, 1996), and Theory of Mind (Blakemore et al., 2003).

All learning systems make assumptions on timing regarding the establishment of units and relatedness

between units in sensory data. Developmental research on infant detection of interpersonal timing could thus be relevant to robotic systems that a) learn through interaction, or b) learn to communicate with other robots or humans, especially with regard to turn-taking behavior. Timing provides a cue to contingent relatedness and might therefore be used to detect the responsive nature of others' behavior onto one's own, i.e. to establish when to consider others' behavior as feedback onto one's own.

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²Note that Murray and Trevarthen (1985) and Nadel et al. (1999) tested 2-month-olds.