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The relationship between infants' interest in feedback of self-performed actions with different latency and their parents' temporally contingent behavior☆

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ABSTRACT

In this study, we asked whether parental contingent behavior and infants' interest in feedback of self-performed actions with different timing are related. Therefore, we observed parents reacting contingently to their infants' behavior and examined the extent to which the infants were interested in real-time visual feedback of their leg movements and delayed visual feedback of their leg movements. Thirty-two parent-infant dyads were tested. Results revealed that the more often parents reacted contingently to their infants' behavior the more infants were interested in the real-time feedback. We concluded that the pattern of parents' contingent behavior influences their infants' interest in immediate effects displayed in the real-time feedback when they are observing displays of their own behavior that differs in latency.

1. Introduction

Developing a sense of self is an important task for infants in order to navigate through the social world. It was proposed that infants discover the self through interaction with others who respond contingently to the infant behavior, because infants experience prompt reactions to their own actions in the environment (Bigelow, 2001). This stands to reason in particular given that part of parental responsive behavior encompasses parents' immediate reactions to their infants' behavior (Papoušek & Papoušek, 1987). However, it is not well understood how parents' immediate reactions to their infants' behavior are related to the infants' development of a sense of self. In this study, we aimed to answer the question of whether these two domains – parents' behavior and infants' sense of self – are related. More specifically, we tested whether the amount of parents' immediate reactions correlates with infants' interest in displays of self-performed movements that differ in latency.

1.1. Temporal contingency of parents' behavior

Parents tend to react promptly to their infants' behavior. This so-called *temporal contingency* has been considered as an independent component of parental behavior (Keller, Lohaus, Völker, Cappenberg, & Chasiotis, 1999). It is independent of

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more general interaction qualities such as parental sensitivity, which is defined as a range of interaction qualities that are contingent, warm, attentive, and appropriate (Ainsworth, Blehar, Waters, & Wall, 1978). Temporal contingency is conceived of as a universal and automatic behavior (Papoušek & Papoušek, 1987). Temporally contingent behavior is sometimes imitative (e.g., the infant smiles and the parent smiles), giving rise to the label "biological mirror" (Papoušek & Papoušek, 1979). Often, however, temporally contingent behavior is non-imitative. This non-imitative behavior occurs either within the same modality (e.g., the infant smiles and the parent raises her eyebrows) or across different modalities (e.g., the infant smiles and the parent vocalizes, Keller et al., 1999). Usually, temporally contingent behavior occurs within around 1 s after the onset of the infants' behavior (Keller et al., 1999; Kärtner, Keller, & Yovsi, 2010).

Two methods have been established to assess parents' contingent behavior: The *responsiveness index* (Watson, 1979) and the *average number of contingent responses per minute* (Keller, Kartner, Borke, Yovsi, & Kleis, 2005). The responsiveness index specifies the conditional probability that the parent responds contingently if the infant displays a behavior. The responsiveness index thus refers to the sufficiency of the infant's behavior to elicit a parental response. That is, the more likely parents are to respond to their infants' behavior within episodes of mutual gaze, the higher is the score on the responsiveness index. The responsiveness index also controls for the absolute number of parental behaviors because the more behaviors the parent displays the more likely it is that a parental behavior is contingent to the infant's behavior by sheer chance. The responsiveness index does not indicate how often the infant receives contingent feedback from the parent within a specific time period, although the index does take into consideration the base rate of both parents' and infants' behavior in the scoring. The average number of contingent responses per minute indicates the amount of parental contingent responses infants receive within a given time frame, although the measure does not consider the base rate of both the parents' and infants' behavior in the scoring.

1.2. Infants' interest in feedback of self-performed actions

Contingent parental reactions might enable infants to experience a causal influence on the environment and to develop expectations about the outcome of their own actions in the external environment. Therefore, this type of feedback differs from infants' experience of perfect contingency between various sensory inputs of self-performed actions. Contingent parental reactions are supposed to signal that another agent is reacting to the self, which in turn might foster infants' self-other discrimination and their sense of self (Bigelow, 2001; Gergely & Watson, 1999; Keller et al., 2005). Part of the sense of self is the sense of self-agency, namely to feel control over an action (Gallagher, 2000). This sense of agency enables a basic differentiation between the self and others. Self-performed actions provide real-time and congruent sensory feedback to a motor command, whereas actions performed by others in response to an infant's behavior do not provide such feedback because this type of feedback is always delayed and not 100% congruent.

Infants' ability to detect self-performed actions is usually tested by showing them two different video images, one of which shows a real-time and congruent view (i.e. as if the infants were looking directly at their own legs) while the other includes a view either of their own actions that are incongruent (i.e., mirror-inverted) or delayed, or another infant's actions. In a seminal study by Bahrick and Watson (1985), five-month-olds were found to look longer at a non-contingent video image of the leg movements of a peer (peer view), or delayed feedback of their own leg movements recorded 10 min prior to the experiment (10-min delayed view), than at a contingent real-time video image of their own leg movements (real-time view). Infants showed this pattern of results irrespective of whether or not they were able to look directly at their own legs. In this study design, the two views differed according to two characteristics: First, infants could have detected spatial relational invariances between proprioceptive and the visual feedback in the real-time view. That is, the position of the legs was congruent for the visual and the proprioceptive feedback in the real-time view but not in the 10-min delayed view or the peer view. Thus, the difference in congruency could have been the basis for the longer looking times at the 10-min delayed view and the peer view. Second, infants could have detected temporal invariances between proprioceptive and visual feedback in the real-time view. That is, the timing of the leg movements matched for the visual and proprioceptive feedback in the real-time view but not in the 10-min delayed view or the peer view. Thus, the differences in timing latency could also have been the basis for the longer looking times at the 10-min delayed view and the peer view.

Follow-up studies aimed to disentangle the relative contributions of congruency and latency for contingency detection. With respect to congruency, it was shown that 3- to 5-month-old infants looked longer at an incongruent view of their own leg movements (e.g., when infants moved their left leg, the right leg moved on the monitor) than at a congruent view of their own leg movements (e.g., infants moved their left leg and the left leg on the monitor moved Rochat & Morgan, 1995); (for similar results see Morgan & Rochat, 1997; Schmuckler, 1996). It should be noted here that both views showed real-time views, meaning that no difference in latency was present. It is assumed that infants want to explore the self and preferably look at the incongruent view because this view provides novel visual-proprioceptive relations. With regard to latency, studies have shown that the ability to differentiate between real-time and delayed video images emerges between 5 and 7 months of age if a view with a delay between 0.5 s and 3 s is contrasted with a real-time view (Hiraki, 2006; Rochat & Striano, 2000; Zmyj, Hauf, & Striano, 2009). It should be noted here that both views showed spatially aligned leg movements, meaning that no difference in congruency was present. These two directions of follow-up studies used very similar methods, as they presented infants with perfectly contingent views: In both views, every infant behavior was followed by a reaction that only differed in congruency or latency.