Selective looking by 12-month-olds to a temporally contingent partner*

Tricia Striano[1,2,3,4], Anne Henning[1], and Amrisha Vaish[1]
[1]Max Planck Institute for Evolutionary Anthropology / [2]Max Planck Institute for Human Cognitive and Brain Sciences / [3]University Leipzig, Center for Advanced Studies, Developmental Sciences, Leipzig, Germany / [4]Vanderbilt University, Department of Pediatrics and Kennedy Center for Human Development, Nashville, USA

Twelve-month-old infants interacted with two strangers in a free-play context. In the Experimental condition (n = 17), one stranger (Contingent partner) vocally responded immediately to infants' looks towards her, whereas the other (Non-contingent partner) was yoked to the Contingent partner with a 1-, 2-, or 3-s delay. In the Control condition (n = 17), the Non-Contingent partner emitted the first vocalization and other non-contingent vocalizations during the free play session. The Contingent partner acted the same as in the Experimental condition. When a novel event occurred after the free-play session, infants looked significantly more to the Contingent partner regardless of condition. The study highlights infants' selective looking to temporally contingent partners in novel situations.

Keywords: social referencing, infant, timing, triadic interaction, dyadic interaction

Infants learn to guide their behavior, in part, by watching people and gathering relevant information from them (Baldwin & Moses, 1996; Feinman, 1982). From an early inclination to monitor others in the context of face-to-face interaction (e.g., Fantz, 1963; Wolff, 1987), infants look to other people in increasingly referential ways as they coordinate their attention between people and objects (Bakeman & Adamson, 1984; Carpenter, Nagell, & Tomasello, 1998; Striano & Rochat, 1999). The emergence of such referential gazing across a variety of contexts is thought to mediate some unique forms of human cognition. With increased referential gazing, infants gain much opportunity to learn about language and the world around them.

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Given the wide array of information available to infants, an overriding question is what is relevant information? It is clear that attending to unnecessary information would result in ineffective learning and the propagation of culture in general (Tomasello, 1999; see also Kaye, 1982). If the infant notices a new object in her environment and immediately hears a new word emitted by an adult, several pieces of information may or may not be important, for example, the tone of voice, whether the speaker is familiar or unfamiliar, whether the speaker has seen the novel object, whether the adult is wearing sneakers or shoes, or has short hair or long.

Human infants do not treat all information alike; rather, they are constrained in ways that assist them to parse and select information (Moses, Baldwin, Rosicky, & Tidball, 2001; Striano & Rochat, 2000). Amodal information such as rate and temporal synchrony may be an especially useful source of information for infants. According to Bahrick and Lickliter (2000), sensitivity to amodal properties "ensures that infants do not relate speech sounds to the color or appearance of a person's clothing, or to the face of an unrelated person, or to a nearby object" (p. 190). In a series of studies, 5-month-olds' perceptual learning was assessed using habituation paradigms, and showed that infants require temporal synchrony between auditory and visual information for effective learning to take place (see also Bahrick, Walker, & Neisser, 1981).

Selecting relevant information becomes especially important as infants engage more systematically in triadic behaviors. These triadic interactions become increasingly robust by the end of the first year (Carpenter et al., 1998) when infants start to check others' attention toward outside entities and situations more systematically. Such abilities are often considered indices of an awareness of intentionality in others (Tomasello, 1999), since understanding the intentions of others requires that infants understand the 'aboutness' or relevance of others' signals toward some third event or situation (Baldwin, 1993, 2000; Tomasello, 1995). This 'relevance' might be determined in part by the timing or contingency of the information. The fact that contingency is readily detected in early infancy (Bigelow & DeCoste, 2003; Nadel, Carchon, Kervella, Marcelli, & Réserbat-Plantey, 1999; Watson, 1972) suggests that it may be an especially good source of information for infants across development (Bahrick & Watson, 1985; Levitt, 1980; Rochat & Morgan, 1995; Schmuckler, 1996; Watson, 1984, 1985). For instance, in dyadic (face to face interaction) young human infants seek out social contingencies that are related to their own behavior (e.g., Nadel et al., 1999). Therefore contingency information might also be important in later development when interactions become increasingly triadic and involve other people in relation to objects or events in the world.

Social referencing studies demonstrate that infants are quite skilled at guiding their own behavior based on the emotional cues people offer them. In these studies researchers generally assess how infants modify their behavior as a function of an adult's expression. For instance, when 12-month-old infants are placed on the deep side of a visual cliff, a Plexiglas surface that gives the impression of depth, they will cross over to the shallow side if their mother poses a positive facial expression but not if she poses a negative expression. When placed on a similar surface with depth cues removed, infants rarely look at their mothers, and when they do look, they do not guide their behaviors as a function of her facial expression (Sorce, Emde, Campos, & Klinnert, 1985). Such findings show that infants use emotional information from others to regulate their behavior in novel situations.

To address the question of infants' understanding of the referential nature of looks, Moses et al. (2001) examined whether 12- and 18-month-olds understand that others' emotions refer to particular objects and events. In one condition, an experimenter who was within the infant's view delivered either a positive or negative vocal emotional outburst while she and the infant were looking at the toy. In the other condition, an experimenter who was out of the infant's view delivered the positive or negative vocal outburst. Infants at both ages modified their behavior as a function of the message source, and disregarded the emotion when it did not refer to the particular object in question. These findings suggest that social referencing cannot be explained only by the temporal contingency of information provided to infants.

Nevertheless, the degree to which temporally contingent feedback may play a role in socially novel or ambiguous situations has not been systematically evaluated. Social information contains both affective (i.e., qualitative) and temporal aspects (Rochat & Striano, 2000). At the affective level, emotional information can be conveyed in the facial expressions that people display as well as the quality or relative attunement of these expressions (Stern, 1985). At the temporal level, this information can be provided in a perfectly contingent fashion (i.e., every time infant looks, mother smiles), in an imperfectly contingent way (i.e., mother smiles only some of the time in response to infant looks), or in a non-contingent way (i.e., mother smiles, but never in response to infant's looks) (see Watson, 1979, 1985). While the role of affective attunement has received much recent attention in studies on early interpersonal communication and intentional understanding (e.g., Gergely & Watson, 1996; Stern, 1985), as well as those on social referencing (Mumme, Fernald, & Herrera, 1996; Mumme & Fernald, 2003; Vaish & Striano, 2004), the role of temporal contingency in these situations is less clear.

To assess the role of timing in infants' looking to others, infants interacted with two female strangers, each of whom provided differing degrees of vocal contingent and/or timing responses in a free-play context. Infants were assigned to one of two conditions: Experimental or Control. In both conditions, the contingent partner always vocally responded to all looks infants directed at her, and the non-contingent partner repeated what the contingent partner had uttered but with intermittent delay. In the Experimental condition, the non-contingent partner only echoed the contingent partner. In contrast, in the Control Condition, besides echoing the contingent partner, the non-contingent partner also emitted the first utterance of the session as well as various utterances throughout the session that were not related to the infants' looks, or to the contingent partners' vocalizations. After the free-play session, a novel toy was suddenly presented from a distance, and infants' looks to the contingent and non-contingent partners were compared across trials. We predicted that infants would be more likely to first look at the contingent than at the non-contingent partner on presentation of the novel sight independent of which of the two strangers began the interaction.

Method

Participants

Thirty-four 12– to 13-month-old infants ($M = 12.37$, $SD = .34$, range = 353–391 days) participated in the study. Seventeen infants (10 males) were randomly assigned to the Experimental condition and 17 (11 males) to a Control condition. One additional infant began the procedure but was excluded due to inattentiveness. Participants were living in Germany. They were White and full-term. In addition, all infants were reported to be healthy at birth and at the time of testing. They had no reported auditory or visual impairments. Infants were recruited from a major city hospital where a research assistant visited their caregivers at the time of the birth of the infants. Infants received a toy or tee shirt for their participation.

Setup and procedure

Experimental condition. Infants sat on a mat and were held by their mothers as they faced two female experimenters who served as the infants' social partners (see Figure 1). Mothers were instructed to look straight ahead and not

preferentially to either side of the room, and to ignore the presentation of the novel toy following the free-play period. Because we wanted to keep the procedure as natural as possible, mothers were told that if infants looked to them, they could nod and say, "Yes!" or "Good!" (the phrase was spoken in German), but that they should not influence the infants' behavior in any other way. After the study was over, mothers were debriefed regarding the experimental conditions and the goals of the study.

Infants were provided with a set of toys (three rattles, nesting cups, two stuffed balls, a manual music box, ABC blocks, and a rubber duck) with which they could play throughout the testing session. The session consisted of three consecutive phases: a baseline, a free-play, and a test phase. The baseline phase lasted 20 s and was designed to assess the extent to which infants may have preferred to look to one partner rather than the other before the experimental manipulation was introduced. Thus, during the 20-s baseline phase, both partners silently looked at the infant with a positive facial expression, and neither partner responded to infants' looking bouts. Following the baseline period there was a 5-min free-play phase during which both partners played with the infant, touching and handling the toys equally. Throughout the free-play phase, both

Figure 1. Experimental set-up.

partners continuously maintained eye contact with the infant and maintained a positive facial expression. The session was video-recorded.

The only variable that differentiated the partners during free play was temporal contingency: the Contingent partner provided perfectly contingent responses whereby she responded promptly to every look infants directed at her by uttering short, positive utterances such as "Good!", "Great!", or "Yeah!"(spoken in German). The Contingent partner responded with such an utterance only once in response to every infant look. The Non-contingent partner, on the other hand, provided non-contingent feedback by simply repeating what the Contingent partner had said but, for each infant, with 1-s, 2-s, or 3-s delay in a non-systematic manner. Once the Contingent partner had responded, the Non-contingent partner responded after counting to 1, 2 or 3 in her head, regardless of infant looking. There were 6 possible orders of timing for the Non-Contingent partner. An analysis of 20 percent of all sessions confirmed that the order of her timing (1, 2, or 3 second delay) was accurate in duration. Furthermore orders showed no systematic pattern and were non-systematic. It is important to note that the non-Contingent adult's behavior was not only temporally delayed but also non-contingent upon infant looking to her face. From the infants' perspective, therefore, the non-contingent adult might have appeared socially responsive but not in relation to them. Given prior research suggesting that infants do not always distinguish between various temporal delays (see Rochat & Striano, 2000) we manipulated both temporal contingency as well as the relevance of the signal directed toward the infant. By yoking the non-contingent adult's behavior to the contingent adult's behavior we could ensure that the amount of information provided to the infant was exactly the same but that the relevance of this information (i.e., timing) differed. Also, given prior research suggesting that infants look longer to adults who provide temporally contingent feedback (see Nadel et al., 1999), yoking the non-contingent adult's behavior to that of the contingent adult ensured that equivalent feedback was provided by each adult.

After 5 min had elapsed, the test phase began. A battery operated toy dog, placed on a table (20 cm long × 30 cm wide × 48 cm high) in between and behind the two partners, was activated for 5 s by a third experimenter who was out of the infant's view. The remote controlled dog was visible to the infant throughout the entire session and prior to its activation. When activated, the toy dog's face moved up and down, and it produced high-pitched barking noises. During the 5-s activation of the dog and the 5 s following the activation, the partners remained unresponsive, silently looking at the infant with a positive facial expression. They then resumed playing normally for another 20 s. The 5 s

during which the dog was active and the 5 s following activation served as an observation period during which infants' looks to either partner were tallied. Because we were interested in infants' inclination to look to each social partner, we used number of looks to the adults as the dependent measure. In order to make the testing session as natural as possible, and to obtain as many trials as possible, we used a 5-second cut off point for each trial. This cut-off time of 5 seconds made it impossible to assess the total duration of looks to each social partner (independently of adult vocalization and behavior) but made the experimental session more ecologically valid in general. This sequence (activation of dog, 5-s response period, 20-s play) was carried out 6 times per infant.

The side on which the Contingent and Non-contingent partners sat relative to the infants was counterbalanced across the sample (for half of the sample the Contingent partner sat on the right, and for the other half on the left). To ensure that infants' responses were not dependent on any one female experimenter, which female experimenter was Contingent and which was Non-contingent was also counterbalanced.

Control condition. The set-up for the Control condition was the same as for the Experimental condition, with the exception of the behavior of the Non-contingent partner. To rule out the possible explanation that infants were simply looking to the partner who always responded to them first (i.e., in the Experimental condition, the Contingent partner), in the Control condition the Non-contingent partner emitted the first utterance at the start of the free-play phase. Moreover, while she continued to emit non-contingent responses at 1-, 2-, or 3-s delays as in the Experimental condition, she additionally provided utterances at varied intervals throughout the free-play session so as to counter the effect of the Contingent partner always vocalizing first. Thus, the design of the Control condition was such that the Non-contingent partner provided more vocalizations than did the Contingent partner. However, the Non-Contingent partner in this condition never vocalized when infants were looking at her. We predicted that regardless of who began the interaction (Contingent partner in Experimental condition, Non-contingent partner in Control) or who provided more utterances (equal in Experimental condition, Non-contingent partner in Control), infants would still selectively look at the Contingent partner upon activation of the dog.

Coding categories

Baseline coding. To ensure that infants did not have an initial preference to look to any one social partner, all infants' looks to each partner in the 20-s baseline period were coded from video records. Paired-samples t-tests were conducted, comparing the number of looks to each experimenter, and also comparing number of looks to the Contingent versus the Non-contingent partner. Results showed that infants did not look differentially to any one experimenter during baseline, $t(33) = .50$, $p > .61$, nor did they look more to the Contingent or Non-Contingent partner during baseline, $t(33) = 1.53$, $p > .12$.

Activity of social partners. A coder also coded a random 20% (n = 7) of free-play sessions for the frequency that each partner handled the toys. This was to ensure that experimenters followed protocol and provided infants with the same amount of information overall. Analysis of activity of social partners was conducted using a paired-samples t-test, which indicated that both partners handled the toys equally often, $t(6) = -.86$, $p > .42$.

Infant looking. A primary coder coded the number of times that infants looked to the Contingent versus the Non-contingent partner during the test phase of each trial. To establish reliability, an independent coder scored number of infants' looks to the Contingent versus Non-Contingent partner in a random 20% ($n = 7$) of the sample. There was a 96.43% agreement between the primary and reliability coders. In the case of a disagreement, the primary coder's coding was used for the analyses.

Results

Preliminary analyses revealed no significant gender effects or interactions. Thus, gender was collapsed in the subsequent analyses.

To assess which partner infants first looked to immediately after the dog barked, infants' first looks to each partner across the six trials were tallied and converted into a proportion (with 6 being 100%). A 2-way mixed ANOVA was conducted with Partner (Contingent vs. Non-contingent) as the within-subjects variable and Condition (Experimental vs. Control) as the between-subjects variable. Proportion of first looks directed at each partner was used as the dependent variable.

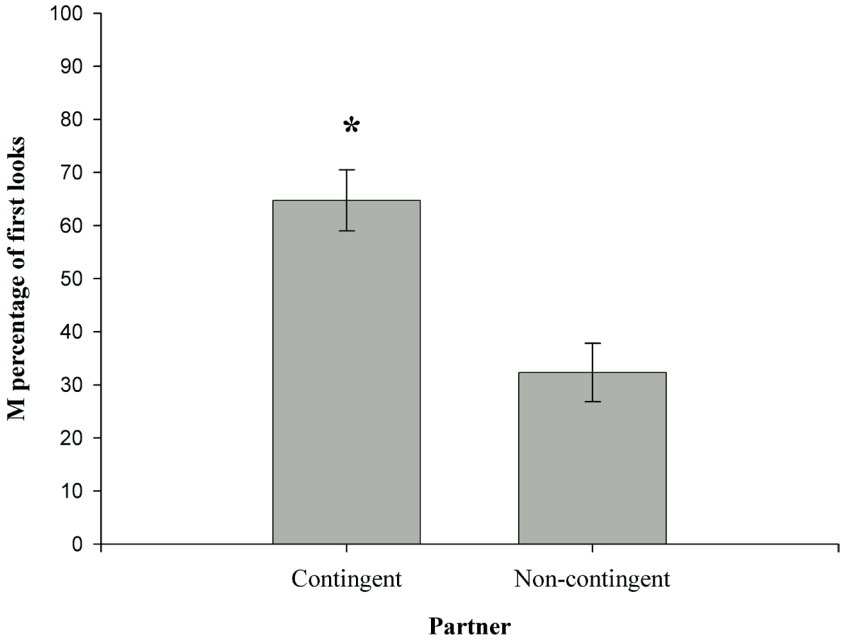

Figure 2. Proportion of first looks to Contingent and Non-Contingent social partners. Note. *$p < .05$.

Proportion of first looks

Confirming our prediction, the analysis revealed that infants directed a significantly greater proportion of their first looks to the Contingent compared to the Non-Contingent partner, $F(1, 32) = 8.75$, $p = .006$ (see Figure 2), regardless of whether infants were in the Experimental or Control condition. That is, there was no Condition by Partner interaction, $F(1, 32) = 0.28$, $p > .60$. There was also no significant condition effect, $F(1, 32) = 1.00$, $p > .32$.

Proportion of total looks

In order to calculate the proportional total number of looks that infants directed to each partner, we counted the total looks to each partner across trials, and converted these numbers into proportions (with each infants' total number of looks to both partners being 100% for that infant). These data were subjected to a 2-way mixed ANOVA with Partner (Contingent vs. Non-contingent) as the within-subjects variable and Condition (Experimental vs. Control) as the between-subjects variable. The analyses showed that infants did not significantly differ in the proportion of total number of looks across the Contingent

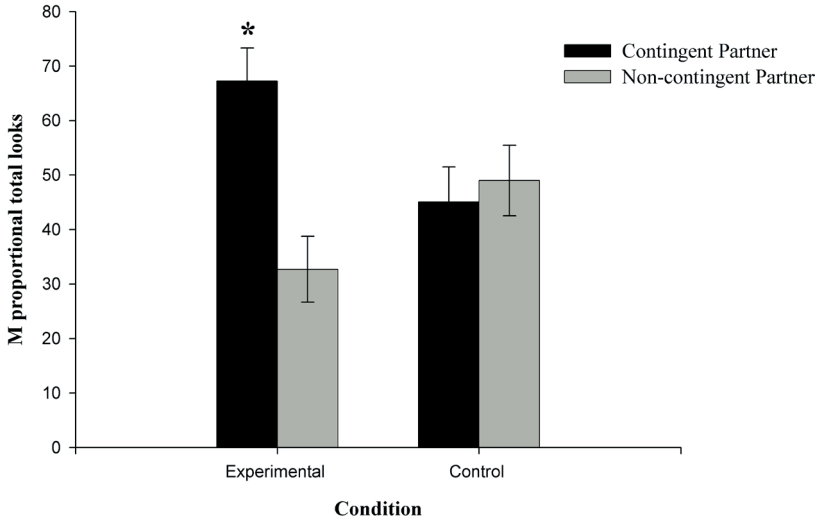

Figure 3. Proportion of total number of looks to each partner as a function of condition.
Note. *$p < .05$.

and Non-contingent partners, $F(1, 32) = 3.40$, $p > .07$. There was also no condition effect, $F(1, 32) = 1.00$, $p > .32$, indicating that the proportional total number of looks by infants in the experimental condition was not significantly different from those by infants in the control condition. There was, however, a significant Condition by Partner interaction, $F(1, 32) = 5.36$, $p = .027$. Simple main effects revealed that in the experimental condition, infants directed more total looks to the Contingent partner than to the Non-contingent one, $F(1, 16) = 8.19$, $p = .011$ (see Figure 3). There was no difference found in infants' total looks in the Control condition, $p > .73$.

Discussion

Parsing, selecting, and determining the relevance of information in order to make decisions, to interact, or simply to get around in the world is a complicated problem. While adults have had much experience that help to build expectations and to guide their decisions, infants have had relatively less experience. The question that we posed in this study was how the infant determines, one year after birth, what is important, and whom to consult when she wants perhaps to show, or learn about, an object, to gather information, or to determine the referent of a new word. Given the range of information available, we argue that infants are particularly sensitive to certain types of information and

that this information guides their selection. One such type of information is temporally contingent information.

In the current study, 12-month-old infants interacted with two strangers who provided different degrees of temporal feedback. The Contingent partner responded each time the infant looked to her and the Non-contingent partner was yoked such that she responded every 1, 2, or 3 seconds after the Contingent partner. This method allowed us to control the overall amount of information that infants received from each person, while varying the relevance of the information. After infants interacted in a free-play phase, a remote controlled dog was activated. Infants' looking to each person was assessed. We found that infants' first looks on a given trial were more often directed toward the Contingent partner. This was true even in the Control condition, in which the Non-Contingent partner emitted the first utterance of the free-play phase and provided more vocalizations than did the Contingent partner. The results support the idea that temporal contingency guides infants' selective gazing to people.

While infants were more likely to look first to the Contingent social partner, they also looked to the Non-contingent partner. The finding that in the Experimental condition, they directed more total looks to the Contingent partner, lends support to our hypothesis that contingency is an important determinant of who infants look to when faced with a novel situation. In the Control condition, however, infants' total looks to each partner were not significantly different from one another. At first glance, this finding seems to go against our hypothesis. However, it is important to recall that in the Control condition the Non-contingent partner provided the first vocalization during the free-play phase, and also more total vocalizations than the Contingent partner. Despite this difference in the social partners' behavior (which could have made the Non-contingent partner more interesting for infants or perhaps more likely to vocalize about the novel situation) infants' total looks to each partner were not different. It is likely therefore that it was the Contingent partner's vocal temporal contingency that made infants look as much to the Contingent as to the perhaps more 'interesting' Non-contingent partner.

There are many sources of information available to infants as they determine where to look, but some sources, such as those that respond immediately and contingently, may be better than others. Sensitivity to timing is an important aspect of all human interaction (Crown, Feldstein, Jasnow, Beebe, & Jaffe, 2002). Furthermore, temporal contingency is likely a form of interaction that infants of all cultures receive, albeit in different ways, and contains information that can be picked up across a variety of modalities such as touch (Stack & LePage, 1996) and face-to-face interaction (Murray & Trevarthen, 1985).

Much research and theoretical accounts point to the role of temporal contingency in both social (Bigelow, 1998; Jaffe, Beebe, Feldstein, Crown, & Jasnow, 2001; Watson, 1972; Gergely & Watson, 1996) and cognitive development (e.g., Haith, 1998; Lewkowicz, 2000). In the current study, infants selectively looked at people and behaved differentially in a novel situation as a function of temporal cues. This finding extends prior work on the relation between temporal contingencies and developing social expectations that have been limited to the early infancy period (Bigelow, MacLean, & MacDonald, 1996; Murray & Trevarthen, 1985; Nadel et al., 1999; Rochat, Neisser, & Marian, 1998). Much research suggests that by the end of the first year, infants start to be aware that people communicate and are sources of information about external entities and events (Carpenter et al., 1998; Tomasello, 1995). At this time, infants also begin to appreciate the referential nature of people's facial and vocal expressions (Moses et al., 2001; Striano & Rochat, 2000), which is a necessary prerequisite to using this information in a selective way. The current study shows that when faced with novel toys, 12-month-old infants tend to look to those adults who have responded contingently to their behavior in the past. The social experiences that promote infants' sensitivity to contingent information likely have their roots in early dyadic interaction (Bigelow, 1998; Gergely & Watson, 1996; Rochat & Striano, 2000). The quality of these interactions influences social expectations in dyadic contexts, and as the current findings suggest, relates to selective looking in later triadic contexts. It is possible that infants first learn about the relevance of social cues in dyadic contexts and are then later reinforced to look to people who respond to their behavior in triadic contexts.

We propose that sensitivity to temporal contingency is a necessary underpinning of early selective looking that is essential to understand others' referential intentions. Understanding the intentions of other people requires that signals are about something (Baldwin, 1993, 2000; Tomasello, 1995, 1999) and that these signals are perceived as relevant. Relevant information is determined partly by timing. Ultimately, the selection and parsing of this relevant information affords effective learning of cultural skills that are unique to humans, such as imitation (e.g., Kaye, 1982; Kaye & Marcus, 1978) and language development (Baldwin, 1993, 2000; Tomasello, 1995, 1999) that rest, in part, upon an awareness of others' intentions.

This proposal also receives some support from other domains. For instance, research with children with autism points to differences in attention to perfect versus imperfect contingencies when compared to typically developing controls (Gergely & Watson, 1999; Nadel, Guerini, Peze, & Rivet, 1999). Interestingly, autism is generally related to other deficits in a range of social cognitive

skills such as language and imitation skills (Carpenter, Pennington, & Rogers, 2002; Charman & Baron-Cohen, 1994; Rogers, 1999). All of these skills require sensitivity to interpersonal timing. Clearly, these links are speculative, and further research is needed to assess the relation between sensitivity to temporal contingency and other aspects of social cognition. The current study shows that temporal contingency helps to guide infants' looking behavior in novel situations. We do not, however, propose that temporal contingency determines all the looking behavior of infants in novel situations. That is, infants most likely use a variety of social cues (such as gaze direction or tone of voice) to determine which types of information are most relevant for them. Our findings fit with previous research on infants' selective looking. For example, Striano & Rochat (2000) tested 7- and 10-month-old infants' selective looking toward a social partner who was looking at them and responding contingently, or looking away while actually monitoring them on a TV monitor and thereby providing contingent feedback. Interestingly, when the social partner was looking away but nevertheless providing contingent feedback, infants at 10 months did not look selectively. That is, they looked equally to the look away-contingent partner before and after a novel event, indicating that they were not looking to this partner for information about the event. We propose that infants are also attuned to and do consider contextual factors beyond contingency, such as gaze direction (Moses et al., 2001), emotions (Phillips, Wellman, & Spelke, 2002), and familiarity (Zarbatany & Lamb, 1985) of others in selective looking and action.

A final word about the implications of this study. Although we did not test for social referencing behavior, and can therefore not determine whether contingency plays a role in infants' referencing behavior, we can nevertheless speculate about such a possibility. In our study, infants were initially exposed to Contingent and Non-contingent partners, and were then exposed to a novel situation. This general paradigm is quite similar to that used in several social referencing studies (e.g., Hornik, Risenhoover, & Gunnar, 1987; Mumme et al., 1996; Mumme & Fernald, 2003; Walden & Ogan, 1988), wherein infants are first exposed to certain familiar or familiarization conditions and, subsequently, their behavior toward novel conditions are judged. While the effect of temporal contingency on social referencing has not been assessed systematically, our findings suggest that it may play at least some role in determining who infants look to for information, and that infants may selectively use information from contingent partners to guide their behaviors. Future research can address this question by manipulating contingency in social referencing paradigms.

In sum, our study shows that all else being equal, timing plays a role in selective looking by 12-month-olds. Such selection is necessary to parse information and for efficient learning to occur (Baldwin, Baird, Saylor, & Clark, 2000). Sensitivity to temporal contingency is therefore likely to be an important contributor in the development of human cultural learning.

Note

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Correspondence regarding this paper may be sent to Tricia Striano, Max-Planck-Institute for Human Cognitive and Brain Sciences, Stephanstrasse 1a, 04103 Leipzig, Germany. E-mail: striano@cbs.mpg.de

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Authors' addresses

Tricia Striano
Max Planck Institute for Human Cognitive and Brain Sciences
Stephanstrasse 1a
04103 Leipzig
Phone: +49-(0)341–9440–123
striano@cbs.mpg.de

Amrisha Vaish
University of Chicago
Psychology Department
5801 South Ellis Ave.
Chicago IL, 60637
amrisha@uchicago.edu

Anne Henning
Max Planck Institute for Evolutionary Anthropology
Deutscher Platz 6
04103 Leipzig
Phone: +49-(0)341–3550–834
henning@eva.mpg.de

About the authors

Tricia Striano received her M.A. and Ph.D in Psychology (Cognition and Development) from Emory University (Atlanta, GA). She was director of the Junior Research Group on Cultural Ontogeny at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, between 2000–2005. In 2004 she was awarded the Sofja Kovalevskaja Prize from the Alexander von Humboldt Foundation, donated by the Federal Ministry of Education and Research. In this context, she is now affiliated with the University Leipzig, Center for Advanced Studies, and the Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany. Her research focuses on the development and neural underpinnings of human social cognition in infancy.

Anne Henning received her M.A. in Psychology (Clinical and Community) from the University of Turin, Italy, in 2002. She is currently a Ph.D candidate in Psychology (Development) at the Max Planck Institute for Evolutionary Anthropology, Junior Research Group on Cultural

Ontogeny, in Leipzig, Germany. Her research focuses on the development of intersubjectivity in early ontogeny, especially on the role of "time and timing" in early social interactions. She has also conducted research on maternal attunement in behavior and speech.

Amrisha Vaish is a M.A. candidate at the University of Chicago, Department of Psychology. She was a guest student scientist at the Max Planck Institute for Evolutionary Anthropology, Junior Research Group on Cultural Ontogeny. She has published in the area of early social referencing and her research focuses on early social cognition.