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Joint Attention and Object Learning in 5- and 7-Month-Old Infants

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We examined the effects of joint attention for object learning in 5- and 7-month-old infants. Infants interacted with an adult social partner who taught them about a novel toy in two conditions. In the *Joint Attention* condition, the adult spoke about the toy while alternating gaze between the infant and the toy, while in the *Object Only* condition, the adult looked to the toy and to a spot on the ceiling, but never at the infant. In the test trials following each social interaction, we presented infants with the 'familiarization' toy and a novel toy, and monitored looking times to each object. We found that 7-month-olds looked significantly longer to the novel toy following the *Joint Attention* relative to the *Object Only* condition, while 5-month-old infants did not show a significant difference across conditions. We interpret these results to suggest that joint attention facilitated 7-month-old infants' encoding of information about the familiarization object. Implications for the ontogeny of infant learning in joint attention contexts are discussed.

Key words: Joint Attention; Triadic Attention; infancy; cognition; learning

INTRODUCTION

Early joint attentional interactions require an infant to monitor another's attention in relation to the self and to an outside object, and are considered to provide the basis for many aspects of infant learning, including language acquisition (e.g. Baldwin, 1995; Dunham & Moore, 1995; Tomasello, 1995). Infant engagement in triadic attention from 9 months has been the subject of much

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study (e.g. Carpenter, Nagell, &Tomasello, 1998), and it is well documented that by this age, infants engage systematically in joint attention interactions involving the infant, an adult partner, and an external object. However, the function of joint attention at and before 9 months has received little attention.

Necessary Skills For Joint Attention

Recent studies have provided evidence that the skills leading to the sensitivity to, and systematic use of joint attention develop much more gradually than previously thought. Striano and Stahl (2005), for example, showed that infants as young as 3 months of age clearly discriminate triadic from non-triadic contexts. In their study 3-, 6- and 9-month-olds varied their gazing and smiling depending on whether an adult social partner coordinated visual attention and affect with them, coordinated only affect or visual attention, or ignored the infants in triadic social interactions including an infant, and adult, and an object. This suggests that already at 3 months of age, infants are sensitive to a number of cues from social partners that are required for later engagement in joint attention.

Gaze following is an important requisite skill for successful utilization of joint attention interactions. Indeed, by definition, joint attention requires the sharing of attention between an infant and another person (Carpenter et al., 1998). Some convincing data come from Hood, Willen, and Driver (1998), which showed that 3-month-old infants looked more frequently and more quickly to a target that corresponded to an adult's shift in eye direction. In this study, the adult's face was presented on a video screen, and only the eyes moved. Thus, as young as 3 months, infants appear able to perceive an adult's eye movements, and to act upon changes in eye direction alone (see also D'Entremont, 2000; D'Entremont, Hains, & Muir, 1997). It is clear that by 7 to 9 months, these gaze following behaviours are robust (Woodward, 2003; see also Flom Deak, Phill, & Pick, 2004). While we have some knowledge about infants' ability to follow others' visual attention, much less is understood about how infants may use others' attentional cues to learn about the world.

Functions of Joint Attention in Early Infancy

Evidence for functional outcomes in triadic contexts involving infant-object-other is remarkably lacking for infants younger than 9 months of age. While many studies indicate that infants modify their own behaviour according to the social signals they receive, little is known about the influence of the social partner's behaviour on infants' processing of the object world. Given that infants frequently learn about the outside word in social contexts, it is surprising that only a few studies have examined this topic.

Reid, Striano, Kaufman, and Johnson (2004) investigated object processing among 4-month-old infants in a recent event-related potential (ERP) study. In this study, infants viewed an adult's face on-screen, and the eyes of the adult gazed to one of two objects. In the following test trials, infants viewed the objects a second time. 4-month-old infants exhibited enhanced neural processing of the *uncued* object during test trials (i.e. the object to which the adult did not look), suggesting that the *cued* object (i.e. the object to which the adult looked) was more familiar to the infant than the uncued object. The data strongly suggest that cueing of an object through adult gaze significantly enhanced object processing in 4-month-old infants.

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In addition, two other studies have provided evidence that the social environment has an effect on infants' efficiency in encoding information about new objects. In one study with 4-month-olds and their mothers interacting through play episodes, infants whose mothers exhibited less active encouragement during play (i.e. less physical and verbal encouragement to touch, look at, and manipulate the object) showed higher novelty preference on a separate task—the type of visual preference that is associated with superior information processing (Miceli, Whitman, Borkowski, Bautgart-Ricker, & Mitchell, 1998). Itakura (2001) found that in 9- to 13-month-old infants, looking behavior was significantly affected by a preceding social event. Infants observed either the mother point to one of two line drawings (social event) or saw one of the line drawings blink (non-social event). In both conditions infants looked longer to the stimulus-enhanced drawing (i.e. the one that was pointed at or blinked). However, when the line drawings were presented alone (without pointing or blinking), only the infants who were in the social condition showed a significant difference in their preference for the drawing that was pointed at *versus* the one to which the mother did not point.

In a previous study (Striano, Chen, Cleveland, & Bradshaw, 2006), researchers examined the role of joint attention for object learning in 9- and 12-month-old infants. An experimenter spoke to an infant about a new object (a toy) in two conditions. In the *Joint Attention* condition, the experimenter alternated her gaze between the toy and the infant while speaking about the toy in a positive tone of voice, with phrases such as 'Oh it's so pretty' or 'Look at all the colors'. The *Object Only* condition was identical, except that the experimenter looked to the object and to a spot on the ceiling, but never at the infant while talking about the toy. In the following test trials, infants were presented with the 'familiarization' object and a novel toy. The results indicated that 9-month-old infants looked significantly longer to the novel toy following the *Joint Attention* condition. In contrast, 12-month-old infants looked equally to the novel toy, exhibiting a strong novelty preference across both conditions. The authors interpreted these findings to suggest that a joint attention interaction facilitated object learning at 9 months, while all of the social cues provided were sufficient for 12-month-olds to extract simple information about an object. Although these data demonstrate that infant learning is facilitated at 9 months through joint attention, little is known about whether joint attention may facilitate learning at earlier ages.

In Study 1, we investigated the timing of the transition to joint attentional learning. In order to examine the age at which a triadic interaction begins to enhance infants' object processing abilities, we tested infants at 5 months of age, using a social interactive learning paradigm similar to that utilized with 9- and 12-month-old infants (Striano *et al*., 2006). As a working hypothesis, we predicted that infants at 5 months would not show enhanced learning, as exhibited by novelty preference, across conditions.

STUDY 1: 5-MONTH-OLD INFANTS

Method

Participants

A total of 16 infants were included in the final sample. An additional 6 infants were tested but not included in the final sample due to fussiness ($N = 3$),

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technical problems ($N = 2$), or looking to only one toy during test trials ($N = 1$). The final sample included 9 males and 7 females, with an average age of 5 months, 20 days (range: 5 months, 5 days to 6 months, 6 days). All infants were from a middle sized city in the east of Germany and were recruited from our lab database, which contains a list of infants whose caregivers had expressed interest in participation in child development studies. Infants were given a small toy (stuffed animal) for participation.

Procedure

Infants were tested in a quiet room of our infant laboratory, in an area surrounded by white curtains to prevent visual distraction. Infants were seated on their caregiver's lap. A table was directly in front of the infant, and an adult experimenter sat across the table from the infant, about 70 cm away (see Figure 1). Each experiment took place in two phases. In the familiarization phase, an adult female experimenter spoke with the infant about an object placed on the table approximately 40° to the right or the left of the infant (counter-balanced across infants). During the following test phase, the familiarization object was paired with a novel object, placed opposite the infant and equidistant from the familiar object on the table, and infant looking times to each object were recorded. Two video cameras captured the experiment; one captured the infant's face and the two toys on the table, and the other recorded the overall experiment. A white screen was lowered from the ceiling to block the infant's view before the beginning of the experiment, and as the experimenter arranged the toys on the table (see Figure 2).

The experimental session began when the curtain was raised to reveal the adult experimenter sitting across the table from the infant. After establishing eye contact with the infant, the experimenter (E1) removed a piece of cardboard blocking the infant's view of the familiarization object (one of four similarly shaped toys including a cat, a monkey, a frog, and a chicken). E1 then smiled, and spoke in a positive tone of voice to the infant about the object, saying phrases such as 'Oh it is nice', or 'So many colors'. In a within-subject design, infants received two conditions, counterbalanced for order of condition, familiarization toys used, and the sides to which the toys were placed. During the familiarization phase in the *Joint Attention* condition, E1 spoke to the infant about the toy while

Figure 1. Set-up for familiarization phase (shown with a 5-month-old infant).

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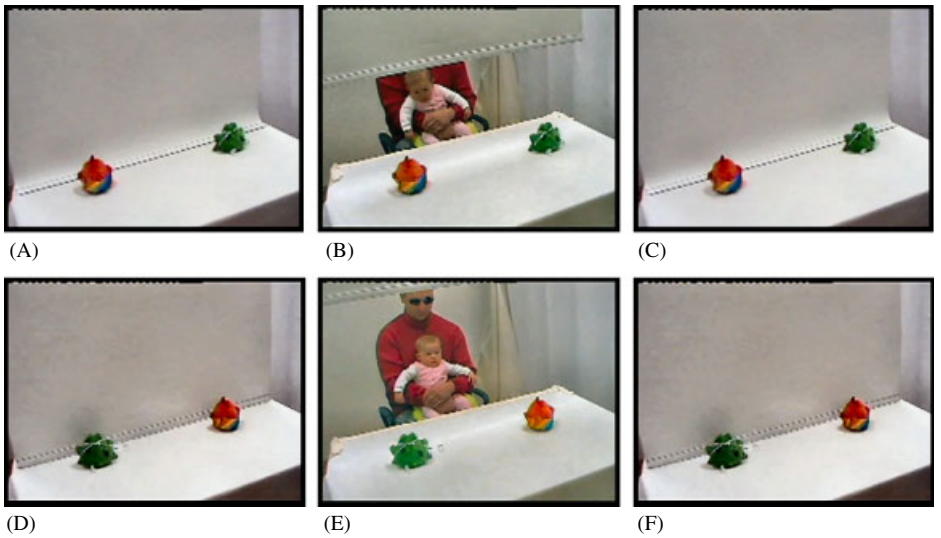

Figure 2. Test trials (shown with a 7-month-old infant). Following the familiarization phase, a curtain is lowered and the experimenter places the familiarization toy and a novel toy on the table (A). The curtain is raised to reveal the toys to the infant. The test trial begins when the infant has looked to one of the toys (B). After 10 seconds, the curtain is lowered (C) and the experimenter reverses the left–right positions of the two toys (D). The curtain is raised and the test trail begins when the infant looks to one of the toys (E) and ends with the curtain being lowered after 10 seconds (F).

alternating gaze between the toy and the infant, alternating gaze approximately every 2–3 seconds. The *Object Only* condition was identical with respect to the number of E1's head movements, positive affect, and phrases spoken, but E1 alternated gaze between the toy and a spot on the ceiling, never looking at the infant.

A second experimenter (E2) located behind a curtain and out of the sight of the infant, monitored the amount of time the infant spent gazing to the toy during the familiarization phase. The phase ended when the infant accumulated 20 s of looking time to the toy. E2 then used a remote control to lower the curtain onto the table, and E1 placed a novel object on the table with the familiarization object. The objects were equidistant from the infant, with one placed to the infant's right and one placed to the infant's left. E1 then hid behind a curtain, and E2 raised the curtain to reveal the two toys to the infant. The test phase began when the infant looked to either toy, and lasted 10 s total. Infants' looking times to the familiar and novel objects were recorded. After 10 s, the curtain was lowered, and E1 reversed the positions of the toys, and the curtain was raised again. The second test phase was identical in procedure to the first test phase. Infants were excluded from analysis if they looked to only one toy across the two test trials.

In summary, each infant was tested in both the *Joint Attention* and *Object Only* conditions using a within-subject design, with the order of conditions and the toys used counterbalanced across subjects. One complete experiment included the following procedures, in the following order: a familiarization phase for Condition 1, test phases 1 and 2 for Condition 1, a familiarization phase for Condition 2, and test phases 1 and 2 for Condition 2 (see Figures 1 and 2).

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Coding

Video data were scored by a trained coder. An additional 32% of video recordings were scored by a second coder for all measures to assess reliability. Pearson's correlations were 0.94 for gazing during the familiarization phase, 0.92 for gazing during the first test phase, and 0.91 for gazing during the second test phase.

The primary dependent measures were infants' looking times to each object during the test trials. In addition, the following behavioural measures were scored for each infant in the familiarization phase, in order to examine possible correlates of test trial results.

Total duration of the familiarization phase: The total duration of the familiarization phase. Timing began when E1 raised the cardboard to reveal the object, and ended when the infant accumulated 20 total seconds of looking to the familiarization toy.

Total time gazing to E1's face: Total amount of time, in seconds, that the infant gazed to E1's face during the familiarization phase.

Total time gazing to the familiarization object: Total amount of time, in seconds, that the infant gazed to the familiarization object during the familiarization phase. During the experimental procedure, this was timed through the use of computer software. Coding was also conducted after the study to verify that infant looking times were 20 s.

A random 32% of the video-taped experiments were scored to assess the experimenter's head movements, vocalizations, and smiling. This was done to assure that the experimenter's behaviour remained constant across all trials and conditions. No significant differences were observed with respect to any of these variables across conditions.

Analyses and Predictions

For the test trials, a novelty preference score (see Fagan, 1971; Fantz, 1964) was computed for each infant, indicating the percentage of time that the infant gazed to the novel toy. This score was calculated by dividing the amount of time in seconds that the infant looked to the novel toy by the total time gazing to both toys, and multiplying the result by 100, such that the novelty preference score was: ((seconds looking to novel toy)/(seconds looking to novel toy+seconds looking to familiarization toy))*100=Novelty Preference Score. Paired *t*-tests determined if the mean novelty preference score for a particular condition was significantly different from that in the other condition. As a working hypothesis, we expected that 5-month-old infants would not exhibit significant differences in novelty preference scores across the *Joint Attention* and *Object Only* conditions.

Results

Preliminary analyses examining infants' performance during the test trials revealed no significant effects of the infant's sex, order of condition, familiarization object, or side on which the familiarization object was placed. In addition, we found no significant differences across trials 1 and 2 for novelty preference scores. Thus, these variables were collapsed in subsequent analyses.

Figure 3 illustrates the percentage of time that infants looked to each toy during the test trials. We found that novelty preference score did not differ significantly across conditions ($t(15)=0.579$, $p = 0.57$, two-tailed), although there

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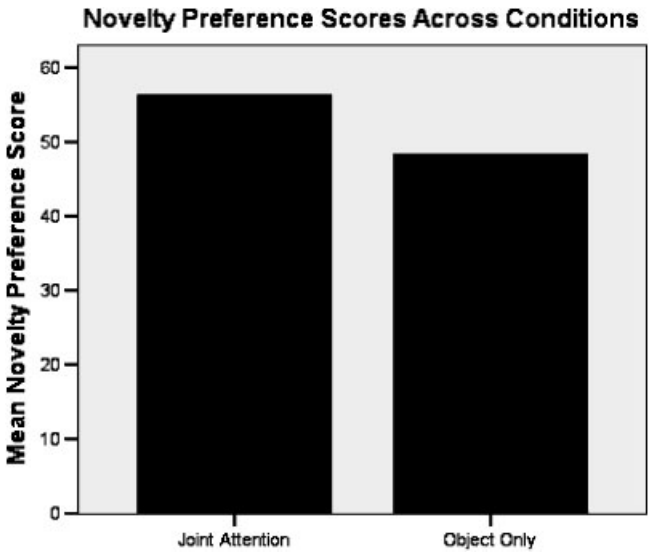

Figure 3. Overall looking times to novel vs 'familiar' objects (5-month-olds). Data for Trials 1 and 2 in each condition are combined. JA=Joint Attention; OO=Object Only; Novel=Novel Toy; Fam=Familiar Toy.

was a non-significant pattern observed in which infants looked longer to the novel toy following the *Joint Attention* condition.

The mean length of the familiarization phase was 1 minute, 50 seconds in the *Joint Attention* condition (S.D.=1.21) and 2 minutes, 40 seconds in the *Object Only* condition (S.D.=1.41). The difference between conditions was not significant ($t(15)=-1.054$, $p = 0.31$, two tailed). The percentage of time that infants spent gazing at the experimenter during the *Joint Attention* condition (M=1.1 min) and the *Object Only* (M=1.7 min) condition did not differ significantly ($t(15)=1.19$, $p = 0.25$, two tailed).

Discussion Study 1

In this experiment, we found that 5-month-old infants did not gaze significantly longer to a novel toy following the *Joint Attention* condition compared to the *Object Only* condition. This finding provides evidence that joint attention does not confer strong learning enhancement in infants of this age. Because previous studies have shown evidence for robust gaze following and other aspects of joint attention by 7 months of age, we next tested 7-month-old infants in the same paradigm. We tested the hypothesis that 7-month-olds would exhibit enhanced object processing, evidenced through longer gazing tomes to the novel toy, following the *Joint Attention* relative to the *Object Only* condition.

STUDY 2: 7-MONTH-OLD INFANTS

Method

Participants

A total of 15 infants were included in the final sample. An additional 11 infants were tested but were not included due to mother interference ($N = 1$), fussiness

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($N = 8$), technical problems ($N = 1$), and looking to only one toy during test trials ($N = 1$). The final sample included 4 males and 11 females, with an average age of 7 months, 14 days (range: 7 months, 1 day- 8 months, 0 days). All infants were from a middle sized city in the east of Germany and were recruited from our lab database, which contains a list of infants whose caregivers expressed interest in participation in child development studies. Infants were given a small toy (stuffed animal) for participation.

Procedure

The procedure was the same as for Study 1 (see above).

Coding

Video data were scored by a trained coder, as for 5-month-old infants (see above). An additional 27% of video recordings were scored by a second coder for all measures to assess reliability. Pearson's correlations were 0.89 for gazing during the familiarization phase, 0.95 for gazing during the first test phase, and 0.92 for gazing during the second test phase.

A random 27% of the video-taped experiments were scored to assess the experimenter's head movements, vocalizations, and smiling. This was done to assure that the experimenter's behaviour remained constant across all trials and conditions. No significant differences were observed with respect to any of these variables across conditions.

Analyses and Predictions

Novelty preference scores were calculated for each infant, as with 5-month-olds (see above). As a working hypothesis, we expected that infants in the *Joint Attention* condition would look significantly longer to the novel object compared to infants in the *Object Only* condition.

Results

Preliminary analyses examining infants' novelty preference scores during the test trials revealed no significant effects of the infant's sex, order of condition, familiarization object, or side on which the familiarization object was placed. In addition, we found no significant differences across trials 1 and 2 for novelty preference scores. Thus, these variables were collapsed in subsequent analyses.

We first examined differences in novelty preference scores across conditions. Figure 4 illustrates the percentage of time that infants looked to each toy during the test trials. We found that novelty preference score significantly differed across the *Joint Attention* and the *Object Only* conditions ($t(16)=2.54$, $p = 0.041$, two-tailed). Next, we examined differences in the amount of time that infants spent looking to the novel versus familiarization objects within conditions. We found that infants spent a significantly greater percentage of time gazing to the novel toy relative to the familiarization toy following the *Joint Attention* condition, while looking times to the novel and familiarization toys did not differ significantly from each other in the *Object Only* condition (see Figure 4: for *Joint Attention*: $M=60.5$, S.D.=13.7 , $t(16)=2.54$, $p = 0.022$, two-tailed; *Object Only*: $M=49.65$, S.D.=18.2 , $t(16)=-0.71$, $p = 0.94$, two-tailed).

The mean length of the familiarization phase was 2 minutes, 30 seconds in the *Joint Attention* condition (S.D.=1.97) and 2 minutes, 12 seconds in the *Object Only*

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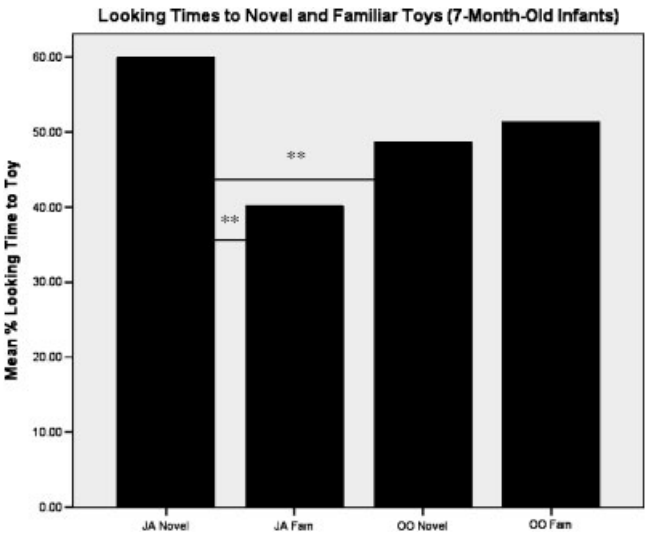

Figure 4. Overall looking times to novel vs 'familiar' objects (7-month-olds). Data for Trials 1 and 2 in each condition are combined. ** indicates a difference significant at the 0.05 level. JA=Joint Attention; OO=Object Only; Novel=Novel Toy; Fam=Familiar Toy.

condition (S.D.=1.40). The difference between conditions was not significant ($t(16)=-0.26$, $p = 0.93$, two-tailed). The percentage time that infants spent gazing at the experimenter during the *Joint Attention* condition (M=1.4 min) and the *Object Only* (M=1.2 min) condition also did not differ significantly ($t(16)=0.301$, $p = 0.77$, two-tailed).

Discussion Study 2

We found a significant difference between conditions in terms of novelty preference score. Specifically, our between-condition comparison (*Joint Attention* versus *Object Only*) indicated that infants exhibited higher novelty preference scores following the *Joint Attention* compared to the *Object Only* condition. This finding was reinforced by within-condition comparisons of looking times to novel vs. familiar objects. Infants showed a significant difference in looking times across objects within the *Joint Attention* condition only.

GENERAL DISCUSSION

In this set of studies, we found that social context significantly impacted infants' object processing outcomes in 7-month-old, but not in 5-month-old infants. Specifically, we found that 7-month-old infants looked significantly longer to a novel toy following the *Joint Attention* condition relative to the *Object Only* condition. In contrast, 5-month-old infants did not show significantly different looking patterns across conditions. Using the interpretation that novelty preference reflects greater stimulus encoding (e.g. Hunter & Ames, 1988), our results suggest that interacting with objects in triadic contexts facilitated object

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processing in 7-month-old, but not in 5-month old infants. The present results provide evidence for a gradual, rather than an abrupt transition to the utilization of joint attention for learning in infancy.

In a recent ERP study with 4-month-old infants, Reid *et al*. (2004) presented infants with a televised image of an adult experimenter. The adult gazed either toward or away from an object. When the objects were presented to the infants a second time, objects that had not been cued by the gaze of the adult were perceived as 'less familiar' by the infants, evidenced by enhanced neural processing. The ERP stimuli were similar to the *Object Only* interaction in the live study, in that infants watched an adult look toward objects, but no attempt was made by the adult to engage the infant in face-to-face interaction. These results, coupled with our own behavioural data, suggest that even at 4 months of age, eye gaze direction can not only affect infant attention, but may also influence the information gathered and processed by the infant.

The 5-month period, tested in the present study, appears to represent a transitional time. Although infants did not show a significant novelty preference following either the *Object Only* or the *Joint Attention* condition, the looking patterns show a trend toward novelty preference following the *Joint Attention* condition. This non-significant trend suggests that a gradual cognitive shift may begin to occur at 5 months, and that infants might be shifting toward a greater integration of social cognitive skills which facilitate joint attention. Future research investigating patterns of neural activity and behavioural responses in 4-, 5- and 6-month-old infants will help to elucidate these issues.

For the first time, we present data showing significant functional outcomes of triadic attention in terms of infants' object processing for 7-month-old infants. In a study examining infants' developing understandings of relationships between adults and objects, Woodward (2003) also found that 7- and 9-month old infants did not respond to a change in an adult's relationship with an object when *only* gaze was available as a social cue. When gaze and an action (grasping the object) were combined, infants responded to a change in actor–object relations. Although we did not manipulate objects in the present study, these results are consistent with our own, suggesting that at 7 months, gaze to an object alone is not sufficient for information processing, while joint attention facilitates information encoding.

ERP data from a recent study with 9-month-olds are also consistent with our present and recent findings. Striano, Reid, and Hoehl (2006) employed an ERP joint attention paradigm using a live, rather than a televised, adult interactant. In a *Joint Attention* condition, an adult interactant gazed to the infant's face and then to a novel object displayed on a screen. In the *Non-Joint Attention* condition, the adult gazed only to the object. The ERP component examined was one that is well-mapped and thought to reflect attentional arousal and/or attentional orienting. The results showed that this component was enhanced (i.e. a larger peak amplitude was observed) during object processing when infants were engaged in the joint attention interaction compared to the non-joint attention interaction. Given our current data, it is unclear how joint attention skills, in terms of object learning, change between 7 and 9 months. Future studies should investigate more fully the range of specific skills involved in functional outcomes.

In conclusion, we found that infants at 5 months and 7 months of age differed with respect to the social cues that enhanced their abilities to extract information about a novel object. At 5 months, infants did not look significantly longer to the novel object in one condition relative to the other. In contrast, at 7 months of age,

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infants looked significantly longer to a novel object following the *Joint Attention* condition only. This suggests that joint attention enhances infants' abilities to learn about objects in the surrounding environment at this age, and also suggests a functional use of joint attention by 7-months of age. Coupled with previous data, we suggest a gradual, rather than an abrupt model of the transition from dyadic to joint attentional learning during the first post-natal year.

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