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Brief report

The effects of joint attention on object processing in 4- and 9-month-old infants

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Abstract

In this study, we examined the effects of joint attention on object processing in 4- and 9-month-old infants. An adult experimenter differed social cues while speaking to infants about a novel object. Only 9-month-olds showed evidence of enhanced object processing following a joint attention interaction.

Keywords: Joint attention; Triadic interactions; Infancy; Learning; Cognition

Joint attention is considered to provide the basis for shared experiences necessary for many aspects of infant development and 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 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, and adult partner, and an external object. However, the function of joint attention at and before 9 months has received little attention.

In order to utilize a triadic social interaction, infants must be attuned to the actions of others, and to modify their own behavior according to those actions. Recent studies provide evidence that the skills leading to the sensitivity to, and systematic use of joint attention develops 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. 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 a requisite skill for successful utilization of joint attention contexts. Indeed, by definition, joint attention requires the sharing of attention between an infant and another person (Carpenter et al., 1998). Some studies have suggested than infants as young as 2–3 months will engage in gaze following (Churcher & Scaife, 1982; Scaife & Bruner, 1975), although the data from these studies suggest that infants of these ages perform only at chance level. More convincing data come from studies such as those by Hood, Willen, and Driver, (1998), which showed that 3-month-old

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infants looked more frequently and more quickly to a target that corresponded to an adult's shift in eye direction. It is clear that by 7–9 months, these gaze following behaviors are robust (Woodward, 2003).

With respect to performance in joint attention behaviors, Striano and Bertin (2005) tested a group of 5–10-month-old infants in a variety of tasks, including coordinated attention, gaze following, point-following, teasing, and means-end tasks. Their results provided evidence that a number of the cognitive underpinnings of triadic attention engagement are present by 7 months of age, and that even by 5 months, some infants exhibited successful performance in some tasks. However, 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 behavior according to the social signals they receive, little is known about the influence of the social partner's behavior on infants' processing of the object world. There are but a few exceptions. This is surprising, given how often infants learn about the outside word in social contexts.

Reid, Striano, Kaufman, and Johnson (2004) investigated object processing among 4-month-old infants in a recent event-related potential (ERP) 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. Four-month-old infants exhibited neural evidence that the *cued* object (i.e. the object to which the adult looked) was more familiar to the infant than the uncued object. In addition, two other studies have provided evidence that social settings have 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, Brautgart-Rieker, & Mitchell, 1998). Additionally, Itakura (2001) found that in 9–13-month-old infants, attention to an object was significantly affected by a preceding social event, and that infants showed attentional preference toward objects cued by the mother through pointing.

In this study, we investigated the effects of differing social interactions on object processing in 4- and 9-month old infants. Specifically, we engaged infants in one of two infant-object-other social interactions to examine the cues that infants use to extract information about novel objects within social contexts. As a working hypothesis, we predicted that joint attention would facilitate object familiarity in both 4- and 9-month-old infants.

1. Participants

The final sample included 30 4-month-old infants with a mean age of 4 months, 23 days (range: 4 months, 6 days–5 months, 6 days) and 30 9-month-old infants with a mean age of 9 months, 2 days (range: 8 months, 17 days–9 months, 10 days). Participants were recruited from a database of caretakers who had previously expressed interest in having their infants participate in development studies. All participants were living in a mid-size city in the east of Germany. Infants were given a small gift (a toy or t-shirt) for participation. An additional 18 infants were tested, but were not included due to fussiness ($N = 8$), looking to only one toy during both of the test phases ($N = 3$), or technical difficulty ($N = 4$) or grabbing a toy during the test phase ($N = 2$). In one case, the parent indicated that the infant had one of the toys at home; this infant was also excluded.

2. Apparatus and stimuli

Participants were tested in a quiet room in the infant laboratory. White curtains surrounded the study area to prevent visual distraction. Two video cameras recorded the experiment: one captured the infant's face and included views of the toy(s), and the other recorded the actions of the experimenter (E1). A white screen was lowered from the ceiling to block the infant's view as E1 arranged the toys on the table. A second experimenter (E2) was positioned out of view of the infant, monitoring the infant on a video screen, and signaled to E1 as to when certain phases of the experiment began and ended.

The experiment consisted of two phases. During the familiarization phase, infants were seated on a parent's lap, with an experimenter (E1) sitting directly across a table covered with a plain white tablecloth, about 70 cm from the infant. During the familiarization period, one object (a stuffed dolphin or turtle) was placed midway between the infant and E1 approximately 40° to the right or the left of the infant. To avoid results based on an a priori preference for a specific toy, the dolphin and turtle were randomly assigned as familiarization objects and counterbalanced across

the participant sample. The side to which the object was placed was also counterbalanced. During the test phase, the familiarization object was paired with a novel object, which was placed opposite the infant and equidistant from the familiar object, 40° to the infant's right or left. The side to which the familiarization object was placed on the first test trial was counterbalanced across infants.

3. Procedure

The experimental session began when the screen was raised to reveal the familiarization object (shielded with a piece of cardboard) and E1. After eye contact with the infant was established, E1 removed the cardboard, and with a positive facial expression, encouraged the infant to look at the toy, using phrases such as "Oh it's so nice", or "So many colors", with a positive tone of voice. Behind a curtain, and out of the sight of the infant, a second experimenter (E2) monitored when the infant looked to and away from the familiarization object, and pressed a computer key to manipulate the computer's timing accordingly. Once the infant accumulated a total of 20 s total looking time toward the familiarization object, the screen was lowered.

Infants were randomly assigned to one of two familiarization conditions. In the *Joint Attention* condition, E1 looked alternately at the infant and the familiarization object. In the *Object Only* condition, E1 looked alternately to the object and to a spot on the ceiling above the object, but never at the infant. In all other ways, E1's actions did not differ between conditions. The goal of testing the two conditions was to determine whether an adult simply looking to and talking about an object is sufficient for infants' object familiarity, or whether joint attention cues (looking to the infant and the object) significantly enhance the infant's ability to extract information required to become familiar with the object.

Immediately following the familiarization phase, infants were tested in two 10 s trials in which the familiarization object was paired with a novel object. The objects were placed on the table by E1, who was behind the screen and out of the infant's view. After placing the objects on the table, E1 hid behind a curtain and could not be seen by the infant during the test trials. The screen was then raised, revealing the toys to the infant. Timing began when the infant looked to one of the two toys, and ended after 10 s. The screen was then lowered, the position of the objects was reversed, and then screen was raised again for a second trial. The second trial was identical to the first except for the placement of the two objects, and the right–left positioning of the novel object on the first trial was counterbalanced across participants.

4. Coding

Video data were scored by a coder blind to the experimental hypotheses. An additional 30% of 4-month-old video recordings were scored by a second coder to assess reliability. Pearson's correlations were: 0.89 for gazing during the familiarization phase, 0.92 for gazing during the first test phase, and 0.93 for gazing during the second test phase. For 9-month-old videos, 27% of video recordings were scored by a second coder to assess reliability. Pearson's correlations were: 0.87 for gazing during the familiarization phase, 0.96 for gazing during the first test phase, and 0.94 for gazing during the second test phase. A random 30% of the video-taped experiments were scored to assess the experimenter's head movements, vocalizations, and smiling. No significant differences were observed across conditions.

The primary dependent measures were infants' looking times to each object during the test trials. In addition, the following behavioral 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 and total looking time to E1's face during the familiarization phase. 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.

Preliminary analyses with infants' novelty preference scores during the test trials as the dependent measure revealed no significant effects of the infant's sex, familiarization object, or side on which the familiarization object was placed. Novelty preference scores across test trials 1 and 2 were also not significantly different. Thus, these variables were collapsed in subsequent analyses. A univariate analysis of variance (ANOVA) with novelty preference score as the dependent variable and infant age (4 or 9 months) and condition (*Joint Attention* versus *Object Only*) entered as factors indicated a marginally significant age × condition effect ($F_{1,56} = 3.497$, $p = 0.067$). Nine-month-old infants differed significantly across conditions with respect to novelty preference scores ($t(28) = 4.03$, $p = 0.05$). Novelty preference scores were significantly higher in the *Joint Attention* condition compared to the *Object Only* condition, as shown in

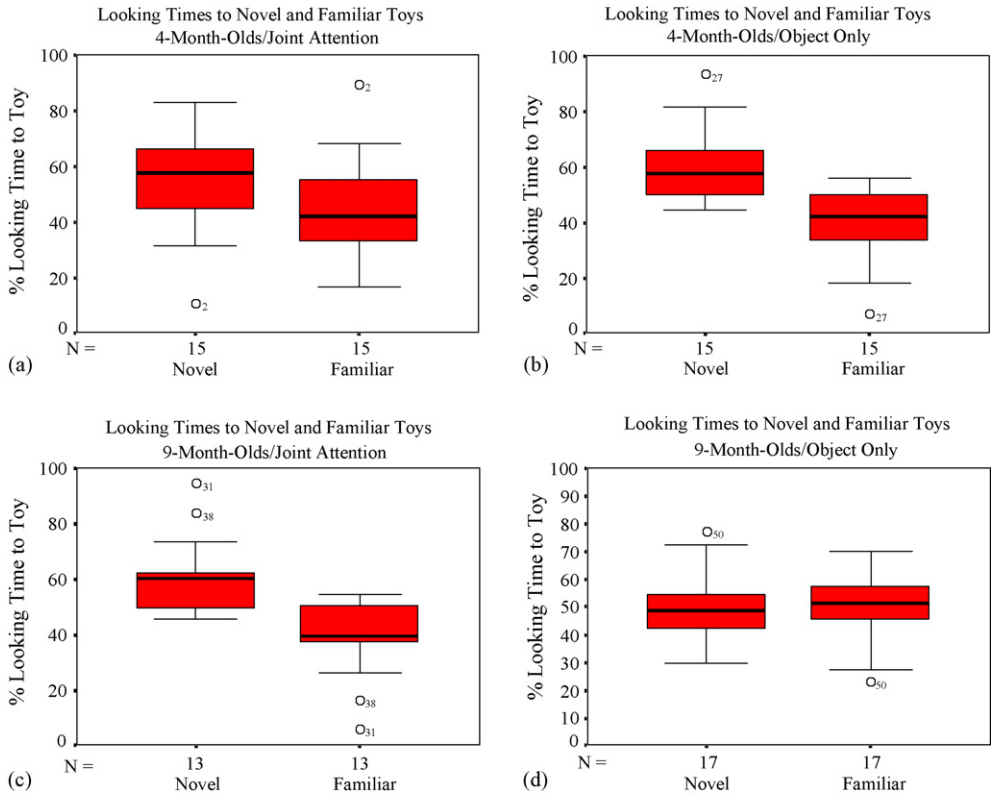

Fig. 1. Four- and 9-month-olds' looking times during test trials, reported as percent time looking to each toy (novelty preference score), by condition.

Fig. 1, which illustrates the percent looking time to each object. Infants' mean novelty preference score following the *Joint Attention* condition was 61.0 and 50.5 following the *Object Only* condition. We also performed the same analyses using only the duration of first looks to each toy (see Colombo, 1993). Paired sample *t*-tests revealed that 9-month-olds looked longer to the novel toy relative to the familiar toy following both the *Object Only* and *Joint Attention* conditions (*Joint Attention*: ($t(12) = 3.56$, $p = .07$; *Object Only*: $t(14) = 3.78$, $p = .01$). Significant differences were not observed among 4-month-olds.

With respect to infants' behavior during the familiarization phase, we found no significant differences across ages or conditions for the length of the familiarization phase. We did find a significant age effect for the amount of time that infants gazed to the experimenter's face during the familiarization phase ($F_{1,56} = 3.762$, $p = .05$). The mean percentage of time that infants gazed at the experimenter during the *Joint Attention* condition was 51.2%, and was 50.1% in the *Object Only* condition for 4-month-olds, and was 40.0%, and 43.3% in the *Joint Attention Object Only* conditions, respectively, for 9-month-olds (see Fig. 2). Within age groups, paired samples *t*-tests indicated that these differences were not significant across conditions ($p > 0.15$ in all cases).

In this study, we found that social context significantly impacted infants' object processing outcomes in 9-month-old, but not in 4-month-old infants. Specifically, we found that 9-month-old infants looked significantly longer to a novel toy following the *Joint Attention* relative to the *Object Only* condition. In contrast, 4-month-old infants' novelty preference scores did not differ significantly as a function of condition. 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 processing in 9-month-old, but not in 4-month-old infants. Given that 4-month-old infants looked longer to the adult experimenter during the familiarization phase, it is likely that 4-month-old infants allocated attentional resources to the adult rather than to the object. These findings are consistent with those of Hood et al. (1998) with infants of this age group.

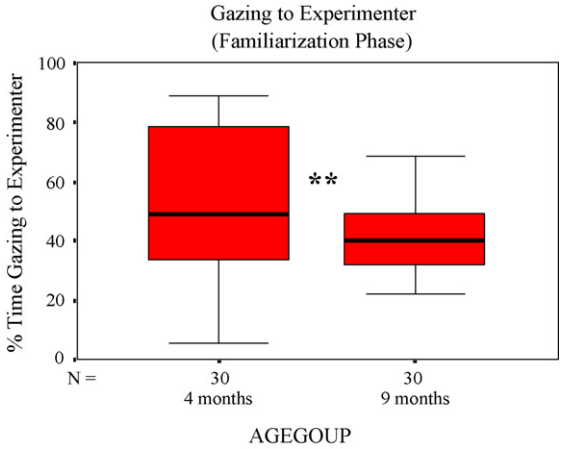

Fig. 2. Four- and 9-month-olds' looking times to the experimenter's face during the familiarization phase (all conditions combined).

For the first time, we present data addressing the functional outcomes of triadic attention in terms of infants' object processing for 9-month-old infants. In a study examining infant's 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. These results are consistent with our own, suggesting that at 9 months, gaze to an object alone is not sufficient for information processing, or at least that combined social cues aid infants more significantly than gaze alone. Our present findings fit well with previous evidence that infants begin to engage systematically in joint attention interactions at around 9 months of age, while adding information about the nature of the functional outcomes.

One possibility is that 9-month-old infants were confused by the adult looking to the ceiling during the *Object Only* condition. However, we found that infants at both ages did not significantly alter the amount of time engaged in the social interaction or looking time to the experimenter as a function of condition. This suggests that infants were not disturbed to any great extent by the experimenter's behavior in the *Object Only* condition. In both conditions, the experimenter exhibited a positive facial expression, positive tone of voice, and a consistent number of head movements. The *Object Only* condition lacked, however, one vital component of a joint attention interaction—looking to the infant. Infants at 9 months of age were sensitive to this difference. Our results seemingly contrast with another study with 9–13-month-old infants, which showed that infants show a preference for objects cues by an interactive adult (the mother) (Itakura, 2001). However, it is possible that in Itakura's study, infants were not sufficiently familiarized with the object during the presentation phase, as we attempted here by having infants accumulate 20 s of looking time to the familiarization object. Further, the range of ages in Itakura's study makes direct comparison problematic, as we have found that infants at 12 months show a strong novelty preference following joint attention or non-joint attention contexts (Striano, Chen, Cleveland, & Bradshaw, 2006a).

The present results are consistent with a recent ERP study examining a similar set of questions through neuroscience research. Striano, Reid, and Hoehl (2006b) employed an ERP joint attention paradigm using a live 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.

In conclusion, the results from our present study suggest that 9-month-old infants derive a benefit from joint attention interactions in terms of learning about new objects. In contrast, at 4 months of age, infants did not discriminate (in terms of novelty preference) between the true joint attention condition and a similar condition in which the head movements and vocalizations of the experimenter were controlled. These results suggest functional significance of joint attention for learning by 9 months of age. The timing of the transition between 4 and 9 months of age, however, remains unclear.

Further research should address these issues in infants between the ages of 4 and 9 months to pinpoint the timing of this social-cognitive transition.

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