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Joint attention social cues influence infant learning

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We examined the effects of differing social cues on object processing in 9- and 12-month-old infants. An adult experimenter spoke to the infants about a novel object in two conditions. In the *Joint Attention* condition, the experimenter spoke to the infant about the toy while alternating her gaze between the toy and the infant. The *Object Only* condition was identical, except that she gazed at the toy and at a spot on the ceiling, but never at the infant. In test trials, infants viewed the toy used in the social interaction along with a toy that they had not seen before. We compared the amount of time that infants looked at the novel toy as a function of condition. We found that 12-month-old infants looked at the novel toy equally following both conditions. In contrast, 9-month-olds looked at the novel toy significantly longer following the *Joint Attention* condition relative to the *Object Only* condition. These results suggest that joint attention interactions significantly impacted object processing in the 9-month-old infants, but not 12-month-old infants. The discussion focuses on the potential role of joint attention in early learning.

INTRODUCTION

Joint attention facilitates many aspects of infant learning such as language and imitation (e.g., Baldwin, 1995; Tomasello, 1995). For example, by 18

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months of age, infants use others' gaze toward objects to learn labels for novel objects (i.e., Baldwin, 1993). Joint attention, or triadic attention, involves the infant in relation to some external object or event. In order to utilize a triadic social interaction, infants must be attuned to the actions of others, and use the information provided by others to modify their own behaviour. Cues used by infants to monitor others' behaviour may include emotional signals, eye contact, body movement, and/or an integration of all of these. In recent studies, it has been shown that 3-, 6- and 9-month-olds are sensitive to joint attention interactions, varying their gazing and smiling depending on whether an adult social partner co-ordinated visual attention and affect with them, co-ordinated only affect or visual attention, or ignored the infants in triadic social interactions including an infant, an adult, and an object (Striano & Stahl, 2005). Already at 3 months of age, infants are sensitive to a number of cues from social partners.

In sum, early in development infants are sensitive to the components of joint attention interactions. By the end of the second year, they use cues to learn about the world. There is a gap in our understanding of the function of joint attention in the first year. The function of joint attention for the infant in terms of gaining knowledge about outside objects or learning in general remains poorly understood. Few studies have addressed the question of how triadic interactions facilitate learning about new objects in the surrounding world. Those studies that do exist suggest that joint attention may serve an important function even in the first year. For example, the ability of 4-month-old infants to recognize and discern a familiar stimulus from a novel one is related to maternal behaviour during mother–infant play sessions. Specifically, infants whose mothers are less involved during toy play (e.g., vocalization, visual encouragement of attention) exhibited higher novelty preference—the type of visual preference that is associated with better information processing (Miceli, Whitman, Borkowski, Brautgart-Rieker, & Mitchell, 1998). Itakura (2001) tested older infants (9- to 13-month-olds) to assess whether social and non-social events led to differential behaviour on subsequent visual preference tasks. In this study, infants observed either their 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. Thus, infants' looking behaviour was influenced by the preceding social and non-social event.

In this study, we investigated the effects of differing social interactions on object processing in 9- and 12-month-old infants. Specifically, infants

engaged in two infant–object–other social interactions. In the *Joint Attention* condition, an adult experimenter talked to the infant about a novel toy, while alternating gaze between the infant and the toy. In the *Object Only* condition, the adult looked only at the toy and at a spot on the ceiling, but never at the infant. In test trials immediately following the interaction, infants saw the "familiarized toy" and a novel toy. Infant gazing at each toy was recorded. We worked under the assumption that novelty preference is associated with efficiency in information processing (Colombo, 1993; Miceli et al., 1998). As a working hypothesis, we predicted that joint attention would facilitate object familiarity in both 9- and 12-month-old infants.

STUDY 1: 12-MONTH-OLD INFANTS

Methods

Participants. Participants were 12 12-month-olds (4 girls, 8 boys; age range: 11 months, 27 days to 13 months, 0 days; mean age = 12 months, 14 days) from the Nashville, Tennessee, area. An additional 3 participants started the experiment but were excluded from the final sample for lack of interest in the objects ($n = 1$), for sleepiness ($n = 1$), or for fussiness to the extent that the session could not be completed ($n = 1$). All infants were recruited from a database consisting of names of infants whose caregivers had volunteered to participate in studies of child development.

Apparatus and stimuli. Infants were tested in a quiet room at the host university. Infants sat at a table on the laps of their caregivers facing the experimenter (E1), who sat 70 cm across from them. During the first phase of the experiment (the familiarization phase), one object was placed midway between the infant and E1, approximately 40 degrees to the right or left of the infant (Figure 1). During the test phase (Figure 2), the familiarization object was paired with a novel object; these were placed equidistant from the infant, with one positioned to the infant's right and one to the infant's left. The infant's gaze direction and duration were recorded with a video camera located behind E1. A white paperboard (120 cm × 45 cm × 30 cm) was used to block the infant's view while E1 placed and rearranged the objects on the table. A second experimenter (E2), positioned out of the infant's view, monitored the infant's gaze and signalled to E1 when the various phases of the experiment started and ended. A second video camera, which was located behind the infant, recorded E1's behaviour. The objects used in the study were four stuffed animal toys of similar size and shape (a dog, a cat, a chicken, and a frog). To counteract any *a priori* preference for a

Figure 1. Example of experimental set-up. Familiarization phase.

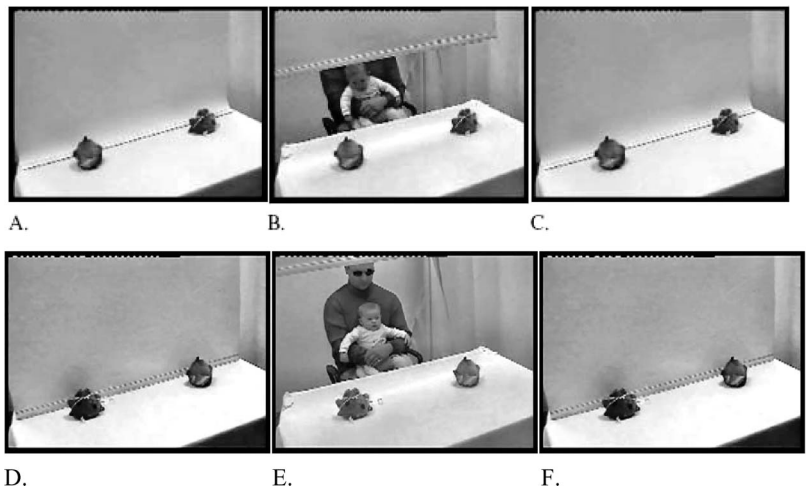

Figure 2. Example of test trials. Following the familiarization phase, a piece of paperboard is placed on the table and the experimenter places the familiarization toy and a novel toy on the table (A). The paperboard is raised to reveal the toys to the infant. The test trial begins when the infant has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

particular object, the objects that served as the familiarization and novel test objects were counterbalanced.

Procedure. The experimental session began when the paperboard was raised to reveal the familiarization object and E1. After eye contact with the infant was established, E1 acted with a positive facial expression and phrases such as, "Oh, nice!" to encourage the infant to look at the familiarization object in one of two social conditions. All infants were tested in both conditions. In the *Joint Attention* condition, E1 looked alternately at the infant and at the familiarization object; in the *Object Only* condition, E1 looked alternately at the familiarization object and at a spot on the ceiling above the familiarization object. The right–left positioning of the familiarization object was counterbalanced across infants. E2 monitored when the infant looked at and away from the familiarization object and pressed a computer key to manipulate the computer's timer accordingly. Once the infant accumulated 20 seconds of total looking time toward the familiarization object, the paperboard was placed in front of the toys, blocking the infant's view. Immediately after the familiarization phase, infants were tested on two 10-second trials in which the familiar object was paired with a novel object. The right–left positioning of the novel object on the test trials was counterbalanced across participants. For test trials, E1 arranged the objects behind the paperboard, then hid behind the paperboard, and was not visible to the infant. The test trial began after the paperboard was raised and the infant first looked at either toy, and continued for 10 seconds. E1 then placed the paperboard in front of the toys and switched the right–left positioning of the two objects. Test trial 2 began when the paperboard was raised and the infant looked at either toy, and ended after 10 seconds.

Coding. All sessions were coded for the two dependent variables from video-tape by a coder blind to the experimental hypotheses. The primary dependent measures were infants' looking time at each object during the test trials. Looking time at the familiar object was operationally defined as any look at the familiar object, and looking time at the novel object was operationally defined as any look at the novel object. For the test trials, a novelty preference score was computed for each infant, indicating the percentage of time that the infant gazed at the novel toy. This score was calculated by dividing the amount of time in seconds that the infant looked at the novel toy by the total time gazing at 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) $\times$ 100 = Novelty Preference Score.

A second observer coded 25% of the tapes for reliability. Interrater reliability, as assessed by Pearson's correlation, was .89.

Results of Study 1

Preliminary analyses revealed no significant effects of sex, familiarization toy, order of conditions, or the side to which the familiarization toy was placed. Therefore we collapsed these variables in subsequent analyses.

Figure 3 shows the mean novelty preference scores for infants across the *Joint Attention* and *Object Only* conditions. Infants did not differ significantly across conditions with respect to novelty preference score (paired sample *t*-test; $p > .50$, two-tailed).

In terms of absolute looking times, following the *Joint Attention* condition, the mean looking duration (in seconds) at the familiar object was 5.13 ($SE = 0.81$), while the mean looking duration at the novel object was 7.69 ($SE = 1.10$). Following the *Object Only* condition, the mean looking duration at the familiar object was 6.11 ($SE = 0.36$) and the mean looking duration at the novel object was 7.94 ($SE = 0.84$).

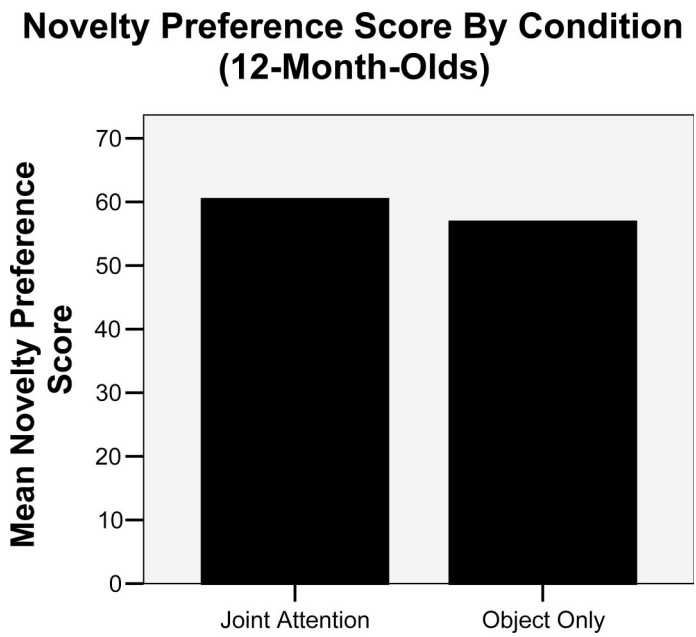

Figure 3. Percentage of time looking at novel object across conditions (12-month-olds).

Discussion of Study 1

The results of this study indicated that 12-month-old infants looked at the novel object longer than the familiar object following both conditions. There was no significant effect of condition. We hypothesized that this could be due to greater competence at 12 months of age to extract general information from an object and the ease of the task. Thus, joint attention *per se* did not influence infant learning. To test this idea, we examined younger infants, who may rely on joint attention cues more heavily for relatively simple tasks. Therefore, we next tested 9-month-old infants in the same paradigm.

STUDY 2: 9-MONTH-OLD INFANTS

Methods

Participants. Participants were 12 9-month-olds (5 girls, 7 boys; age range: 8 months, 11 days to 9 months, 22 days; mean age = 8 months, 29 days) from the Nashville area. An additional 2 participants started the experiment but were excluded from the final sample for lack of interest in the objects ($n = 1$), or for fussiness to the extent that the session could not be completed ($n = 1$). All infants were recruited from a database consisting of names of infants whose caregivers had volunteered to participate in studies of child development.

Apparatus and stimuli. Apparatus and stimuli were the same as for Study 1 (see above).

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

Coding. Coding was conducted as for Study 1 (see above). A second observer coded 25% of the tapes for reliability. Interrater reliability, as assessed by Pearson's correlation, was .91.

The primary dependent measures were infants' looking times at each object during the test trials. 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 at the novel toy. This score was calculated by dividing the amount of time in seconds that the infant looked at the novel toy by the total time gazing at 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.

Results of Study 2

Preliminary analyses revealed no significant effects of sex, familiarization toy, order of conditions, or the side to which the familiarization toy was placed. Therefore, we collapsed these variables in subsequent analyses.

Figure 4 shows the mean novelty preference scores for infants across the *Joint Attention* and *Object Only* conditions. There was a significant difference between conditions in novelty preference score, $t(11) = 2.987$, $p = .012$, two-tailed). As shown in Figure 4, infants looked longer at the novel toy following the *Joint Attention* condition compared to the *Object Only* condition.

In terms of actual looking times following the *Joint Attention* condition, the mean looking duration (in seconds) at the familiar object was 5.18 ($SE = 0.83$), while the mean looking duration at the novel object was 6.43 ($SE = 0.73$). In the *Object Only* condition, the mean looking duration at the familiar object was 6.55 ($SE = 0.87$), and the mean looking duration at the novel object was 4.54 ($SE = 0.63$).

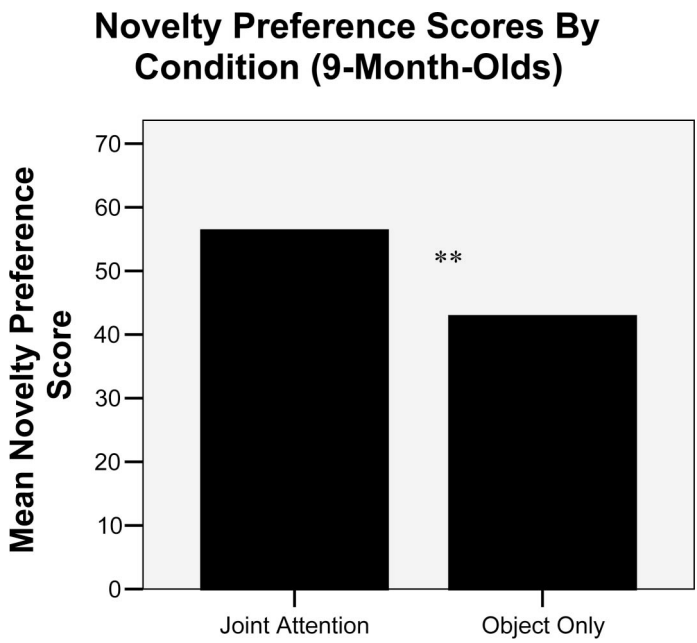

Figure 4. Percentage of time looking at novel object across conditions (9-month-olds). **indicates significance at $p = .05$.

Discussion of Study 2

The results indicated that 9-month-old infants looked at the novel object longer in the *Joint Attention* condition relative to the *Object Only* condition. Following the *Object Only* condition, 9-month-old infants looked at the familiar object longer than at the novel object, suggesting more processing time was needed (see also Richards, 1997). Given that stronger novelty preferences indicate greater information encoding, these results suggest that joint attention significantly enhanced infants' object processing at 9 months of age.

GENERAL DISCUSSION

It is known that joint attention is important for skills such as language learning and imitation, but little is known about its function in early infancy. Here we tested the influence of joint attention on 9- and 12-month-old infants' object processing.

Our results suggest that joint attention enhanced object processing in 9-month-old, but not 12-month-old, infants. Specifically, we found a significant condition effect on novelty preference scores for 9-month-old infants, while 12-month-olds looked equally at the novel toy following both the *Joint Attention* and *Object Only* conditions.

Given previous data that show that 12-month-old infants actively and systematically engage in triadic interactions (see Carpenter, Nagell, & Tomasello, 1998), we were at first surprised with the results of Study 1. We predicted that a joint attention social interaction would significantly enhance object familiarity. In fact, infants at this age appear to benefit from triadic attention in much more complicated tasks. It is clear that infants' use of joint attention does not remain static across infancy, as infants rapidly develop new cognitive skills and make transitions through a number of cognitive shifts. Namy and Waxman (1998) found, for example, that infants at 18 months interpreted both gestures and words for object categories. In contrast, 26-month-olds used words only. The authors interpreted these data to suggest a more generalized learning model for 18-month-olds in which both gestures and words were used in symbolic form. At 26 months of age, the authors suggest that words become predominant.

Similarly, Woodward and Hoyne (1999) engaged 13- and 20-month-olds in a joint attention word-learning task. An adult experimenter showed the baby a new toy, while producing a word and a novel sound (with a noisemaker). At 13-months, infants chose the target toy in test trials when either the word or the sound was produced, while 20-month-olds chose the target only in relation to the word. The authors argue that this provides

evidence that infants at 13 months accept a broad range of signals in communicative contexts, becoming more selective later in development. Our own data also suggest a similar process, with differential behavioural outcomes at different stages of ontogeny. It is likely that 9-month-olds depend on joint attention cues for different tasks than do 12-month-olds. Most likely, the use of social cues depends on the necessity to use these cues. Once a task is mastered the quality of social cues should play less of a role in learning (see also Goubet, Rochat, Maire-Leblond, & Poss, 2006).

Put in this light, our data suggest that 12-month-olds were able to encode information about the familiarization object sufficiently in both conditions, given either set of social cues. By this age, infants may no longer require joint attention for very simple tasks, such as processing general information (e.g., the outward appearance of a small toy). It is likely that 12-month-olds benefit through joint attention in learning more cognitively challenging tasks.

To expand on this hypothesis, we next tested infants at 9 months of age in the same paradigm. At 9 months, infants are just beginning to engage systematically in joint attention interactions, and may benefit from triadic attention in simpler learning contexts. Our data support this hypothesis. At 9 months, infants differed in novelty preference scores as a function of condition, looking significantly longer at the novel toy following the *Joint Attention* condition. In fact, infants looked a greater percentage of time at the familiar, rather than the novel toy following the *Object Only* condition. Given the assumption that novelty preference is an indicator of greater stimulus encoding, these results suggest that infants extracted more information about the toy during the joint attention relative to the object only social interaction.

The behavioural data presented here are consistent with a recent event-related potential (ERP) study with 9-month-old infants. Striano, Reid, and Hoehl (2006) employed an ERP joint-attention paradigm using a live adult interactant. In a *Joint Attention* condition, an adult interactant gazed at the infant's face and then at a novel object displayed on a screen. In the *Non-Joint Attention* condition, the adult gazed only at the object. Results show that the infant brain manifests enhanced processing of objects that are learned in the context of joint attention.

Taken together, these results suggest that joint attention helps enable 9-month-olds to encode basic information about a novel object. In contrast, in the current study, 12-month-olds did not benefit significantly from the joint attention relative to the object only interaction in terms of extracting basic information about the new toy. We suggest that this may reflect an ability at this age to independently extract basic information about new objects in the surrounding world. However, it is clear that older infants and toddlers benefit significantly from joint attention in more complex,

goal-oriented tasks. Future research should test older infants in more cognitively challenging paradigms to gain greater insight into the influence of joint attention. Research is needed to further explore the role of social cues on learning in early infancy.

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