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Original Article

Sex differences in visual attention toward infant faces☆

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ABSTRACT

Parental care and alloparental care are major evolutionary dimensions of the biobehavioral repertoire of many species, including human beings. Despite their importance in the course of human evolution and the likelihood that they have significantly shaped human cognition, the nature of the cognitive mechanisms underlying alloparental care is still largely unexplored. In this study, we examined whether one such cognitive mechanism is a visual attentional bias toward infant features, and if so, whether and how it is related to the sex of the adult and the adult's self-reported interest in infants. We used eye-tracking to measure the eye movements of nulliparous undergraduates while they viewed pairs of faces consisting of one adult face (a man or woman) and one infant face (a boy or girl). Subjects then completed two questionnaires designed to measure their interest in infants. Results showed, consistent with the significance of alloparental care in human evolution, that nulliparous adults have an attentional bias toward infants. Results also showed that women's interest in and attentional bias towards infants were stronger and more stable than men's. These findings are consistent with the hypothesis that, due to their central role in infant care, women have evolved a greater and more stable sensitivity to infants. The results also show that eye movements can be successfully used to assess individual differences in interest in infants.

1. Introduction

Care for infants is a major evolutionary dimension of the biobehavioral repertoire of many species (Clutton-Brock, 1991). For human beings, its evolutionary importance is likely to have significantly shaped cognition to ensure that parents are sufficiently interested in and responsive to infants that they provide steadfast care (Burkart, Hrdy, & Van Schaik, 2009). The underlying cognitive mechanisms, however, are still largely unknown. Here we report a study designed to identify how attention might be attuned to the detection and processing of infant faces, and to examine how attention might vary in strength as a function of individual differences in interest in infants.

Primate infants are costly to rear because of the considerable energy and care they require and because their slow maturation requires care over an extended period (Kaplan & Lancaster, 2003; Kramer, 2005; Lancaster & Lancaster, 1987). By these criteria, human infants and children are the most costly by far (Hrdy, 1999, 2009; Kramer, 2005; Kuzawa, 1998). Despite these costs, humans reproduce at higher rates than the average for Great Apes (Galdikas & Wood, 1990; Sear & Mace, 2008; Sellen, 2007).

Humans reach these high rates through substantial maternal care and unusually high investment by alloparents and fathers. The amount and length of these investments suggest that there are psychological mechanisms to help ensure that children receive the required care. Studies indicate that these mechanisms are triggered, in part, by the qualities that make infants 'cute' and attractive (e.g., large head, large and low-lying eyes) (Gould, 1980; Lorenz, 1971; Tinbergen, 1951). Most adults, for instance, rate images of infants as cuter and more attractive than images of adults (Fullard & Reiling, 1976; Maestripieri & Pelka, 2002), smile more at infant images (Bradley, Codispoti, Sabatinelli, & Lang, 2001; Hildebrandt & Fitzgerald, 1978), look longer at cuter than at less cute infants (Hildebrandt & Fitzgerald, 1978, 1981), are more likely to use infant-directed speech with children with more infant-like features (Zebrowitz & Brownlow, 1992), and are more willing to care for cuter than less cute infants (Glocker et al., 2009a).

Despite advances in our understanding of the behavioral underpinnings of human infant care, little is known, as we said, about the cognitive mechanisms involved. One exception is studies using the dot-probe paradigm, which show that infant faces produce more efficient covert shifts of spatial attention than adult faces. In one study, the greater efficiency was indexed by faster detection of a target cued by an infant face (Brosch, Sander, & Scherer, 2007), in

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another study by greater amplitude of the P1 ERP component and improved discrimination of the orientation of a target cued by an infant face (Brosch, Sander, Pourtois, & Scherer, 2008). These studies suggest that basic attentional processes might be specifically tuned to infant stimuli. Some critical questions, however, remain.

First, the evidence shows that infant faces affect covert attention. It is unclear whether the results will be the same for overt attention. Attention allocation can be accomplished by gazing at a location of interest (overt attention) or by attending to peripheral regions without moving one's eyes (covert attention). Overt attention is sequential so that only one location is fixated at a time, whereas covert attention, at least under some circumstances, can be deployed simultaneously to several regions (Carrasco, 2011; Cave, Bush, & Taylor, 2010). While caring for an infant, the caregiver, as needed, sometimes attends to the infant overtly, including looking at it directly, other times covertly. In social-interactions, however, overt attention is what counts if, as seems likely, direct looks are more rewarding (Ewing, Rhodes, & Pellicano, 2010; Kampe, Frith, Dolan, & Frith, 2001). Mutual gaze is fundamental for nonverbal communication, and infants look longer at faces with direct gaze than averted gaze and show distinctive neural processing to faces with direct gaze (Farroni, Csibra, Simion, & Johnson, 2002; Grossmann et al., 2008). To our knowledge, no study has examined how infant faces affect sustained overt attention. This was one goal of the current study.

Second, questions remain about whether and how much these attentional biases vary between the sexes. Compared to men, women more often pick up and hold infants (Harris, Spradlin, & Almerigi, 2007; Lockard, Daley, & Gunderson, 1979) and, in laboratory studies, show higher interest in and responsiveness to infants (Blakemore, 1981; Feldman & Nash, 1978; Maestripieri & Pelka, 2002), more often use infant-directed-speech when talking to them (Zebrowitz & Brownlow, 1992), prefer their images (Fullard & Reiling, 1976; Maestripieri & Pelka, 2002), are more sensitive to cuteness differences in their faces (Lobmaier, Sprengelmeyer, Wiffen, & Perrett, 2010; Sprengelmeyer et al., 2009), and are faster and more accurate in recognizing their facial expressions (Babchuk, Hames, & Thompson, 1985).

These observations are consistent with comparative and cross-cultural data about parents and alloparents. Typically, mothers are the greatest contributors – about 50% – to direct infant care (Kramer, 2005; Marlowe, 2005), with siblings, grandmothers, and the father contributing to lesser extents (Marlowe, 2005). Human fathers, however, show greater parental investment than the males of other Great Ape species, although their investment is highly variable across individuals and societies (Geary, 2008; Gray & Anderson, 2010; Hewlett, 1992; Marlowe, 2005). Among the several factors that affect male parental investment are the degree to which it contributes to offspring survival and reproductive success, certainty of paternity, and the cost of loss of mating opportunities with other females (Geary, 2008). Thus, although we expect to find sex differences in cognitive mechanisms among humans, these differences are likely to be moderated by greater variability in interest in infants among men than women rather than in a complete lack of interest by men.

For all these reasons, the presumed cognitive architecture that subserves infant care should be sensitive to individual and sex-related differences among adults in how rewarding they think it will be to care for infants. If we consider attentional mechanisms, for instance, it is now widely accepted that the deployment of attention is accomplished through the interactions of two attentional systems (Corbetta & Shulman, 2002), a bottom-up, salience-based system and a top-down volitional system. The former is thought to operate fairly rapidly and automatically in a feed-forward manner (Theeuwes, 1992), whereas the latter system relies on re-entrant projections and therefore takes more time to exert its influence (Theeuwes, 1992; Treisman & Gelade, 1980; Wolfe, Cave, & Franzel, 1989). Studies have shown that both systems give attentional priority to rewarding stimuli (Anderson, Laurent, & Yantis, 2011; Hickey, Chelazz Theeuwes, 2010; Raymond & O'Brien, 2009). Applying this mod the question of infant care, we can speculate that evolution favored a general attentional bias toward infants that is modulate individual differences (e.g., sex differences, mating strategies) and socio-ecological circumstances under which caregiving occurs (viability, social support).

Although the attentional bias for infants can be expressed in b bottom-up and top-down systems, and although we do not precl the possibility that infant-related reward can modulate bottom processing, we assume that individual differences are more evide top-down attention because that system is intrinsically volitional because reward facilitates volitional attention. If voluntary attentic driven by a reward system, attention to infants should be sensitiv the reward that adults ascribe to infants. To date, this hypothesis not been tested.

The current study therefore had two main goals. The first wa examine how infant faces affect sustained overt attention. The sec was to examine whether individual differences in interest in inf are associated with different patterns of overt attention to face different ages (infants vs. adults) and different sexes (male female). To find out, we monitored subjects' eye movements w they looked at pairs of faces, one of an adult, one of an infant. design assumes that both stimuli are competing for attentic resources. We manipulated the relative reward value of the in faces on the premise that most young heterosexual adults wo show special interest in adult faces of the opposite sex (Kranz & Is 2006; Spreckelmeyer, Rademacher, Paulus, & Gründer, 2013). then gave subjects two questionnaires designed to assess tl interest in infants. Given the evolutionary significance of infant c we predicted a general attentional bias to infants and that the deg of attentional bias will reflect individual, including sex-relat differences in interest.

2. Methods

2.1. Subjects

The subjects were 32 men (age: $M \pm SD = 19.38 \pm 1.18$) and women (age: $M \pm SD = 19.29 \pm 1.68$), all undergraduates at Mi igan State University, who participated for course credit. None w parents, and 1 woman reported that she was pregnant. All repor having normal or corrected to normal vision. All checked "white" an ethnicity questionnaire. The sample was selected from a sligh larger sample (69 subjects) based on their descriptions of their sex feelings and sexual fantasies on two 7-point Kinsey scales (Kins Pomeroy, & Martin, 1948). The 63 selected reported being complet heterosexual ($N = 58$) or predominantly heterosexual ($N = 5$). O intent in restricting the sample in this way was to simplify t interpretation of any potential differences in attention between sam vs. opposite-sex adult faces. Finally, one man was removed from t analyses because he acted "uninterested" during the study a inspection of his eye movement data showed that he did not com with the task (e.g., he did not look at either face on many trials).

2.2. Stimuli

The stimuli for the eye-tracking test were frontal views of the fac of young adults and infants, all with neutral expressions. The ad faces (24 men, 24 women) were selected from the *Productive Agi Lab Face Database* (Minear & Park, 2004) and the *FERET* databa (Phillips, Moon, Rizvi, & Rauss, 2000). The infant faces (24 boys, girls, 3 to 6 months old) were selected from the website *Flickr* (ww flickr.com). All faces were of white individuals and, in each age a sex category, showed similar levels of masculinity/femininity a attractiveness (as rated by independent judges).

Faces were standardized to have identical orientation and similar inter-pupil distance, and only the face outline was visible (hair, ears, and original background were removed). Any non-face area of the image region (188 × 250 pixels) was filled with a grey background (RGB: 192, 192, 192).

All color images were transformed to grey-scale, with luminance and relative contrast adjusted to approximate the average luminance-contrast of the sample of adult faces (examples are shown in Fig. 1).

2.3. Interest-in-Infants questionnaires

Interest in infants was based on subjects' answers to two questionnaires, one for *Infant-Job-Preference*, the other for *Interaction-With-Infants*. The Infant-Job-Preference questionnaire lists an infant-care job and 6 other jobs at similar wages (e.g., child care, house keeper, waiter/waitress), according to the Occupational Employment Statistics of the US Bureau of Labor Statistics (U.S. Bureau of Labor Statistics, 2008). Subjects are told that all jobs require the same time and effort and are asked to rate their preference for each job on a seven-point scale, where 1 = "strongly dislike," 2 = "dislike," 3 = "slightly dislike," 4 = neither like nor dislike," 5 = "slightly like," 6 = "like," and 7 = "strongly like." In a prior study, women had a reliably higher preference for the infant care job than men (Cohen's d =0.92) but had similar preferences for the non-infant care jobs. A Desire-To-Have-Children questionnaire (modeled after Rholes, Simpson, Blakely, Lanigan, & Allen, 1997) correlated more with preference for the infant-care job, especially for women (r = .47 for women, r = .25 for men) than for non-infant-care jobs (r = .28 for women and r = .003 for men).

For the *Interaction-with-Infants* questionnaire, modeled after Maestripieri and Pelka (2002), subjects are presented with the following scenario:

> "Several of your friends and some people you do not know are getting together and have invited you to join them. As you enter the room where they have gathered, you notice that in the corner of the room there is a baby lying in a car seat. The baby appears to be about 6 months old. After you enter the room, how likely is it that you would do each of the following?"

Then, three different situations are presented, each describing the infant in a specific emotional state: neutral ("if the baby is lying quietly, I would …"), negative ("if the baby is crying, I would …"), or positive ("if the baby is smiling and cooing, I would …"). Each situation is followed by 6 behaviors that could be performed in response (e.g., "ignore the baby", "go over and look at the baby"). Subjects are asked to indicate, on a 7-point scale (from 1 = "extremely unlikely" to 7 = "extremely likely"), how likely they are to respond in these ways, with higher scores indicating more positive behaviors towards the infant. In a prior study (see Cárdenas, 2010), the questionnaire showed good internal consistency (women = .93; men = .90). A factor analysis did not show that the structure of ratings varied according to the infant's emotional state, so the interaction- with-infants score can be computed by averaging across questions. Analysis also showed that the average rating across items correlated more with preference for the infant-care job (r = .62 for women and r = .51 for men) than with preference for non-infant care jobs (r = .08 for women and r = .2 for men) (for details, see Cárdenas, 2010).

2.4. Procedure

The faces were presented on a 19.7-inch CRT monitor placed 30 cm from the subject, with distance maintained by a chinrest. The display resolution was set to 1024 × 768 pixels with a refresh rate of 85 Hz. Subjects' eye movements were monoculary recorded at a sampling rate of 500 Hz using the head-mounted video-based eye tracking system EyeLink II (SR Research Ltd., Mississauga, Ontario, Canada). Before starting the experimental trials, the manufacturer's procedures were used to calibrate the eye tracker and to validate the eye positions. For calibration, subjects were asked to fixate on a sequence of 9 points that appeared at different locations in the display; the eye tracker was adjusted if necessary until the average tracking error was less than 0.4 degrees of visual angle. The validation procedure assessed the accuracy of the system in predicting gaze position from pupil position using an identical random sequence of 9 points in the display. Once the eye positions were validated, the experimental trials began.

Subjects were told that "we are interested in learning about how people look at faces. You will see a series of pairs of faces while we record your eye movements. You do not have to do anything, just look freely at the faces and the program will change the pictures every 6 s."

Twenty-four pairs of faces were shown, each consisting of one adult face (man or woman) and one infant face (boy or girl). To minimize possible face-specific effects (e.g., that certain faces, independent of age, are more attentionally engaging), each subject received a unique set of randomly paired infant and adult faces. For each pair, one face (~ 8° × 10.5°) was shown 6.5° above the fixation point, the other 6.5° below fixation. Vertical placements were chosen to minimize any possible confound with laterality effects showing that emotional stimuli tend to be more salient in the left visual hemispace (Borod, Zgaljardic, Tabert, & Koff, 2001).

Each face pair was presented for 6 s. Display location (above or below fixation), age (adult or infant) and sex (male or female) were counterbalanced across the 24 trials. Measurement accuracy was reassessed before each trial by asking subjects to fixate on a dot in the center of the screen. If accuracy was low, the eye tracker was recalibrated.

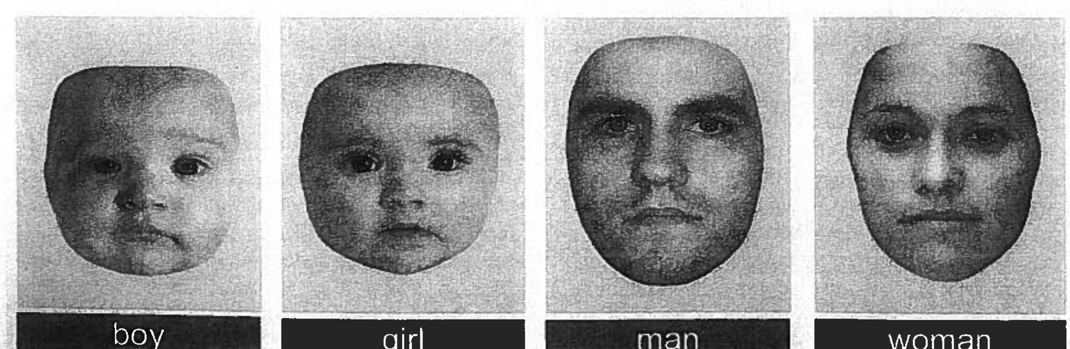

Fig. 1. Examples of faces shown in the visual attention task.

Following this free-viewing task, subjects answered the two interest-in-infants questionnaires, a demographics questionnaire, and several more questionnaires not reported here.

3. Results

3.1. Interest-in-Infants questionnaires

Scores on the Job-Preference questionnaire were examined with a mixed-design ANOVA with job type (infant care, other jobs) as a within-subjects factor and sex of subject (male, female) as a between-subjects factor. The main effect of job type was not significant, $F_{1,60} = 0.46$, $p = .5$, mostly because women and men had similar preferences for non-infant-care jobs (Men: $M \pm SD = 4.28 \pm 0.81$; Women: $M \pm SD = 4.15 \pm 0.77$). For the infant-care job, however, there was a significant interaction between sex and job type, $F_{1,60} = 18.56$, $p < .001$, $\eta_p^2 = .24$, women's preference for the infant care job ($M \pm SD = 5.29 \pm 1.87$, 5 = "slightly like") being significantly higher than men's ($M \pm SD = 3.45 \pm 1.95$, 3 = "slightly dislike"; $t_{60} = 3.80$, $p < .001$, d = 0.96]. Women's mean score also was significantly higher than the scale midpoint (4 = "neither like nor dislike") [$t_{30} = 3.85, p < .001$]; men's score was not [$t_{31} = -1.56$, $p = 0.13$].

On the Interaction-With-Infants questionnaire, women also scored significantly higher ($M \pm SD = 5.73 \pm 0.94$) than men ($M \pm SD = 4.62 \pm 1.02$) [$t_{60} = 4.46, p < .001, d = 1.13$].

To examine the association between the questionnaire scores and eye movements, we computed a composite score (interest in infants) by summing the subjects' z-scores on each questionnaire. The women's mean score was significantly higher than the men's (women: $M \pm SD = .93 \pm 1.46$; men: $M \pm SD = -0.93 \pm 1.65$) [$t_{60} = 4.71, p < .001, d = 0.64$].

3.2. Eye movements

Eye movements were analyzed by creating a region of interest for each face in the display. Three measures of overt attentional bias were considered: location of first fixation, duration of viewing time for each face, and total number of fixations to each face. We included both duration of viewing time for each face and total number of fixations because they are different indicators of visual attention (e.g., even though two people could look at the same face for two seconds, one person could deploy a larger number of fixations to that face than the other person).

3.2.1. Location of first fixation

Because more "attentionally grabbing" objects are more likely to be looked at first, the analysis asked whether the first fixation was to the infant or the adult face. The answer was neither: most subjects instead looked first at the image located above the fixation point (average proportion of trials = .78 for men, .87 for women).

A multilevel logistic regression therefore was used to estimate the probability that subjects looked first at the infant image based on three variables: the image's top–bottom location (0: bottom, 1: top), the pairs shown (boy and man, boy and woman, girl and man, girl and woman), and sex of subject, and the interaction between these variables. The models were fitted with lme4 in R (Bates, Maechler, & Bolker, 2012). A variety of models showed that the only significant predictor (in logits) was whether the image was located on top, *Estimate* ± *SE* = 2.94 ± .13, p < .001. Given this result, no further analyses of first fixation were conducted.

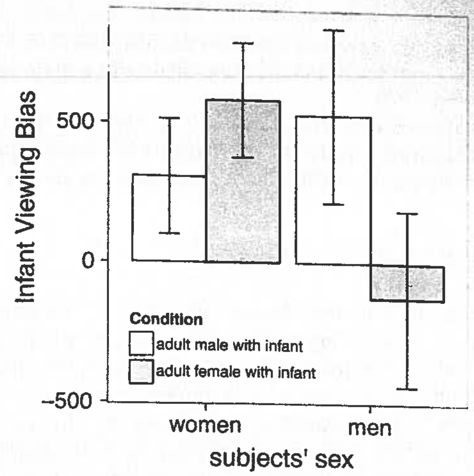

Fig. 2. Men's and women's infant viewing bias as a function of the sex of the adult face. Error bars represent within-subjects 95% confident intervals.

3.2.2. Total viewing duration for infant faces

The next analysis examined each subject's total viewing duration to infant faces compared to adult faces and, more specifically, whether the sex of the adult face affected viewing duration to infant faces. Total viewing duration was defined as the sum of duration scores across all fixations on each face; we calculated a difference score to represent infant viewing bias, by subtracting, on each trial, the viewing time for adult faces from the viewing time for infant faces. Thus, longer viewing durations for infant faces are indicated by positive scores, longer viewing durations for adult faces by negative scores. Table 1 summarizes the mean infant viewing bias for each condition for men and women separately. Fig. 2 shows these scores collapsed across the sex of the infant.

Infant viewing bias scores were analyzed with random intercepts multilevel regression (using maximum likelihood estimation), with trials (level 1) nested within subjects (level 2). Models were estimated with the nlme package in R (Pinheiro, Bates, DebRoy, Sarkar, & R Development Core Team, 2012). Models were compared using likelihood ratio tests.

Table 1
Mean and standard deviation of infant viewing bias for each experimental condition by sex of subject.

Condition	Men (N = 31)		Women (N = 31)	
	M	SD	M	SD
boy with man	370.88	1310.19	308.24	1363.13
boy with woman	−35.23	979.6	717.14	1006.89
girl with man	696.92	1234.51	280.67	1107.38
girl with woman	−216.41	796.74	388.49	975.88

Table 2
Summary of a 2-level random-intercepts model of subjects' looking time bias toward infant faces.

Fixed effects	*Estimate*	*SE*	*t*
Condition 1 (boy–man)	370.88	196.77	1.904⁺
Condition 2 (boy–woman)	−406.11	188.15	−2.160*
Condition 3 (girl–man)	326.04	188.15	1.732
Condition 4 (girl–woman)	−587.29	188.15	−3.121**
Women	−62.65	275.45	−0.227
Condition 2 × Women	815.01	266.09	3.063**
Condition 3 × Women	−353.61	266.09	−1.329
Condition 4 × Women	667.55	266.09	2.508*

+ $p = .057$.
* $p < .05$.
** $p < .01$.

Table 3
Summary of a 2-level random-intercepts model of men's looking time bias toward infant faces.

Fixed effects	Estimate	SE	t
Condition 1 (boy–man)	370.88	174.03	2.131*
Condition 2 (boy–woman)	−406.11	188.96	−2.149*
Condition 3 (girl–man)	326.04	188.96	1.725
Condition 4 (girl–woman)	−587.29	188.96	−3.108**
Interest in infants	360.35	106.97	3.369**
Condition 2 × Interest in infants	−325.43	116.15	−2.802**
Condition 3 × Interest in infants	−72.05	116.15	−0.620
Condition 4 × Interest in infants	−420.64	116.15	−3.622**

* $p < .05$.
** $p < .01$.

A baseline model (unconditional model) without explanatory variables showed that 16% of the variance in infant viewing bias was accounted for by variation across subjects. Adding the predictor experimental condition (boy–man, boy–woman, girl–man, girl–woman) improved model fit ($\chi^2_3 = 9.33$, $p = .025$). Adding sex of subject was not significant ($\chi^2_1 = 0.98$, $p = .323$), but adding the interaction between sex and experimental condition significantly improved model fit ($\chi^2_3 = 25.79$, $p < .001$). The model, summarized in Table 2, shows that men had a positive infant viewing bias when the infant was presented with a man but not with a woman. Women, in contrast, showed a positive infant viewing bias independently of whether the infant was presented with a woman or man.

3.2.3. Relation between infant viewing bias and Interest-in-Infant Questionnaires

The relation between infant viewing bias and interest-in-infants scores was assessed with random intercept multilevel regression. To facilitate coefficient interpretation (and given the large sex difference in the interest-in-infants scores) we examined the contribution of interest in infants for each sex in separate models, and interest-in-infant scores were centered for each sex. The reference model was defined as infant viewing bias predicted by experimental condition.

For men, adding interest in infants improved model fit marginally ($\chi^2_1 = 3.62$, $p = .056$), and including the interaction between the experimental conditions and interest in infants improved model fit significantly ($\chi^2_3 = 17.86$, $p < .001$). The final model for men, summarized in Table 3, shows that men with above average interest in infants tended to look longer at infant faces when infants were paired with adult male faces.

For women, model fit was improved by adding interest in infants ($\chi^2_1 = 9.34, p = .002$) but not by adding the interaction between the experimental conditions and interest in infants ($\chi^2_3 = 0.89$, $p = .827$). These results, however, were influenced by two women who departed substantially from the mean distribution of scores in the interest-in-infants questionnaires. These "outliers," however, behaved in the direction predicted: one women, the one who was pregnant, scored high on the interest-in-infants questionnaires (score = 2.04) and had a strong infant viewing bias; the other woman scored low on the questionnaires (score = −4.59) and had very short infant viewing times. Because these two women nevertheless had a significant influence on the regression models, we excluded them in order to better represent the results of the other 29 women in the sample. The influence of the two "outliers" also suggests that, at least for women, the sample may have been affected by a range restriction. Thus, for the other 29 women, those with above average interest in infants did not have substantially stronger infant viewing bias.

Fig. 3 summarizes the relationship between interest in infants and infant viewing bias according to the sex of the adult face and subjects' sex.

3.2.4. Fixation bias for infant faces

As another indicator of attentional bias, each subject's total number of fixations to infant faces compared to the number of fixations to adult faces was examined on each trial, using multilevel binomial regression (with lme4 in R), with fixations on infant faces scored as "successes" and fixations on the adult faces as "failures," and with fixations nested within subjects. Compared to a model without explanatory variables, a model that included experimental conditions (boy–man, boy–woman, girl–man, girl–woman) showed significantly improved fit ($\chi^2_3 = 13.86, p = .003$). Model fit was not increased by adding sex of the subject ($\chi^2_1 = 1.46, p = .227$) but was significantly increased by adding the interaction between sex of the subject and experimental conditions ($\chi^2_3 = 44.98$, $p < .001$). The coefficients, summarized in Table 4, show that men were more likely to fixate on the infant face when it was paired with an adult male face, whereas women were more likely to fixate on the infant face in all conditions.

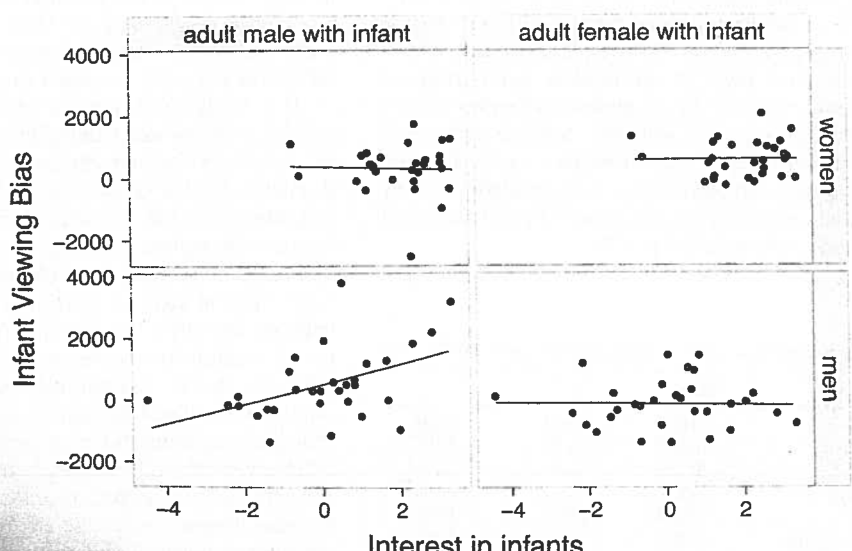

Fig. 3. Relationship between infant viewing bias and interest in infants as a function of the sex of the adult face and subjects' sex. Interest-in-infants scores are shown centered around the mean score for men.

Table 4
Summary of a 2-level random-intercepts model of subjects' fixations toward infant faces.

Fixed effects	*Estimate*	*SE*	*z*
Condition 1 (boy–man)	0.098	0.052	1.877+
Condition 2 (boy–woman)	−0.168	0.052	−3.205**
Condition 3 (girl–man)	0.118	0.053	2.226*
Condition 4 (girl–woman)	−0.202	0.053	−3.816**
Women	−0.050	0.074	−0.677
Condition 2 × Women	0.323	0.074	4.380**
Condition 3 × Women	−0.097	0.074	−1.314
Condition 4 × Women	0.260	0.074	3.520**

+ $p = .06$.
* $p < .05$.
** $p < .01$.

3.2.5. Relation between fixation bias for infant faces and Interest-in-Infant Questionnaire

The relation between fixation bias for infants and interest in infants was also examined with binomial multilevel regression. For each sex, a reference model was defined with fixations on infant faces vs. fixations on adult faces as the dependent variable predicted by experimental condition (boy–man, boy–woman, girl–man, girl–woman). As before, the interest-in-infants composite score was centered for each sex.

For men, compared to the reference-model, the main effect of interest in infants was not significant ($\chi^2_1 = 1.71$, $p = .190$). However, the interaction between interest in infants and experimental conditions significantly improved model fit ($\chi^2_3 = 7.99$, $p = .046$). The model, summarized in Table 5, shows that men with above average interest in infants tend to fixate more often on the infant face than the adult face, and that this effect was more evident when the infant face was paired with an adult male face.

For women, as with the infant viewing bias data, interest-in-infants scores were not significantly related to their pattern of fixations.

3.2.6. Relation between attentional bias measures and image statistics

A series of multilevel regressions was performed to determine whether the pattern of attentional bias observed (i.e., total viewing duration and total fixations for infant faces) could be accounted for by the image statistics (i.e., area, apparent contrast across 8 spatial frequency bands) (Delplanque, N'diaye, Scherer, & Grandjean, 2007). Trials represented the first level in all models while subjects represented the grouping variable. In all models, difference scores were used as predictors (e.g., the apparent contrast difference between the infant and adult faces was used to predict the total viewing duration for infant faces). None of the image statistics or their interactions with sex and experimental condition reached statistical significance on likelihood ratio tests (all $p > .05$).

Table 5
Summary of a 2-level random-intercepts model of men's fixations toward infant faces.

Fixed effects	*Estimate*	*SE*	*z*
Condition 1 (boy–man)	0.095	0.053	1.809
Condition 2 (boy–woman)	−0.163	0.053	−3.105**
Condition 3 (girl–man)	0.115	0.053	2.179*
Condition 4 (girl–woman)	−0.195	0.053	−3.685**
Interest in infants	0.062	0.033	1.908+
Condition 2 × Interest in infants	−0.054	0.033	−1.640
Condition 3 × Interest in infants	0.010	0.034	0.306
Condition 4 × Interest in infants	−0.067	0.033	−2.013*

+ $p = .056$.
* $p < .05$.
** $p < .01$.

4. Discussion

In this study, we explored a possible implication of the evolutionary significance of infant care for visual attention, namely, whether young adults, even young nulliparous adults, show overt attentional biases toward infant faces and whether such biases are modulated by individual differences, including sex differences, in interest in infants.

The results showed that men and women respond differently to infant and adult faces. Women looked longer at and fixated more often on infant than at adult faces of either sex, whereas men looked longer at and fixated more often on infant faces only when paired with an adult male face. The two measures of eye movements, viewing time and number of fixations, showed similar patterns of results. On the interest-in-infants questionnaires, women also scored higher than men; their scores, however, were not consistently associated with their looking times to infant faces, possibly because of the restricted range of their interest scores, with most scores concentrated in the higher end of the scale. In contrast, for men, interest in infants was positively associated with eye movement measures when infant faces were paired with the face of an adult male. For men, the positive association supports the interpretation that this pattern of results was due to men's degree of interest in infants and not to their intention, for instance, to avoid looking at men's faces. Notably, none of these patterns were accounted for by the low-level image properties that we examined, such as the faces' relative contrast across spatial frequencies. The results also suggest that individual differences in interest in infants and their cognitive correlates are more likely to be detected in men inasmuch as men's interest in infants and degree of parental investment are more variable than women's.

The overt attentional bias toward infant faces is consistent with the hypothesis that human cognition is attuned to infant care. It is possible that this attunement reflects the importance that cooperative breeding played in human evolution (Hrdy, 1999, 2009), particularly because the subjects were non-parents looking at unrelated infants and because the bias, although less reliably, was observed in men and not just in women. We previously cited comparative and cross cultural data suggesting that human infant care, unlike that of non-human apes, includes an exceptional degree of allomaternal care, including care provided by men. Our results are consistent with these observations. Alternatively, this attunement could be also be the expression of a developmental mechanism aimed at preparing nulliparous individuals for parenthood, in other words, to enhance the chances that such individuals would gain the necessary parental skills to successfully raise their offspring (e.g., learning-to-mother hypothesis) (Fairbanks, 1990; Lancaster, 1971). Further work is needed to directly assess these possibilities.

This research is only a first step toward characterizing the cognitive mechanisms underlying interest in infants. Although our work shows a link between overt attention and self-reported interest in infants, further work is needed to determine the direct impact of this attentional bias on actual infant care. In addition, future studies that include a more representative sample of the different reproductive stages in humans (e.g., children, adolescents, parents, grandparents) may be able to determine whether this attentional bias is a constant and persistent bias or changes with development. Research on the relationship between sex differences in this attentional bias and endocrine fluctuations may provide insight into how attention to infants is regulated by neuroendocrine systems. Finally, we believe that understanding the cognitive mechanisms underlying interest in infants is worthwhile not just from a basic science perspective but also from its potential significance for application and remediation, since parental investment can be affected by an array of factors, including the infant's physical appearance (Daly & Wilson, 1984; Dion, 1972; Mann, 1992; Waller, Volk, & Quinsey, 2004), genetic relatedness (K. G. Anderson, 2005), paternal certainty (Anderson, Kaplan, & Lancaster, 2007), parental depression (Lovejoy, Graczyk, O'Hare, & Neuman, 2000), and social support (Gameiro et al., 2011; Runyan et al., 1998).

Ultimately, we hope that a better understanding of the cognitive and biobehavioral mechanisms underlying interest in infants not only can improve our understanding of how these mechanisms translate into actual care-giving, but how, through the development of new screening and assessment tools, persons at risk for poor care-giving can be identified early enough so that interventions can be instituted before care-giving fails.

Supplementary Materials

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.evolhumbehav.2013.04.001.

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