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Perceptual Specialization and Configural Face Processing in Infancy

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Abstract

Adults' face processing expertise includes sensitivity to second-order configural information (spatial relations among features, such as distance between eyes). Prior research indicates that infants process this information in female faces. In the current experiments, 9-month-olds discriminated spacing changes in upright human male and monkey faces but not in inverted faces. However, they failed to process matching changes in upright house stimuli. A similar pattern of performance was exhibited by 5-month-olds. Thus, 5- and 9-month-olds exhibited specialization by processing configural information in upright primate faces but not in houses or inverted faces. This finding suggests that, even early in life, infants treat faces in a special manner by responding to changes in configural information more readily in faces than in non-face stimuli. However, previously reported differences in infants' processing of human versus monkey faces at 9 months of age (but not at younger ages), which have been associated with perceptual narrowing, were not evident in the current study. Thus, perceptual narrowing is not absolute in the sense of loss of the ability to process information from other species' faces at older ages.

Discrimination of faces is an important aspect of social interaction, and humans use several types of information for this purpose (Maurer, LeGrand, & Mondloch, 2002; McKone & Robbins, 2011; Mondloch, LeGrand, & Maurer, 2010). A critical type of information is *second-order spatial relations*. Diamond and Carey (1986; also see Carey & Diamond, 1994) used the term second-order relational information to describe the specific distances between the features of the face (e.g., the distance between the eyes). Faces are relatively unique in that the gross configural information (what Diamond and Carey term 'first-order relational information'; e.g., the eyes being *above* the nose) is identical for every face. Therefore, according to Diamond and Carey, adults use second-order relational information, in addition to featural information (e.g., shape of the eyes), to efficiently process faces. Diamond and Carey (1986) also suggested that the ability to use second-order relational information is necessary to gain expertise in face processing.

Prior research has documented infants' sensitivity to second-order configural information in female faces at 3, 5, and 7 months of age (Bhatt, Bertin, Hayden, & Reed, 2005; Hayden,

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Bhatt, Reed, Corbly, & Joseph, 2007; Quinn & Tanaka, 2009; Thompson, Madrid, Westbrook, & Johnston, 2001). The current research examined whether this capacity extends to human male and monkey faces and to house stimuli. Typically, infants have less experience with males than with females (Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002; Rennels & Davis, 2008), and very little (if any) exposure to monkeys. Moreover, prior research (discussed below) indicates that infants discriminate between female faces more readily than between male faces at 3 months of age (Quinn et al., 2002; Ramsey, Langlois, & Marti, 2005; Ramsey-Rennels & Langlois, 2006), and between human faces more readily than between monkey faces at 9 months of age and in adulthood (Mondloch, Maurer, & Ahola, 2006; Pascalis, de Haan, & Nelson, 2002; Pascalis et al., 2005; Scott & Monesson, 2009). Thus, if second-order relational processing in infancy is confined to categories of stimuli to which one has extensive exposure, then it is possible that infants would fail to detect second-order configural changes in human male and monkey faces even though they detect similar changes in female faces. On the other hand, if infants detect spacing changes among features in human male and monkey faces as they do in female faces, then it would suggest that the processing of second-order relational information in infancy extends to primate faces in general, and does not require extensive experience with a particular subcategory of stimuli (Mondloch et al., 2006).

To examine the limits of specialization and configural processing, we also tested infants on house stimuli. Adults do not process spacing information in house stimuli as well as they do in faces (Leder & Carbon, 2006; Robbins, Nishimura, Mondloch, Lewis, & Maurer, 2010). Robbins et al. (2010) report that spacing changes have to be four times as large in house stimuli as in human face stimuli for adults to exhibit the same level of discrimination. Such differences in adults' performance on face stimuli versus house stimuli have been thought to indicate specialization for face stimuli. If infants process spacing information in faces but not in matched house stimuli, it would suggest that the specialization for faces exhibited by adults has its origins early in life and that configural processing contributes to this specialization. If, on the other hand, infants discriminate spacing information in house stimuli, it would indicate that configural processing is not confined to faces, thereby suggesting that faces are not a "special" class of stimuli in infancy at least as it pertains to second-order relational processing.

We also examined the relationship between second-order relational processing and perceptual narrowing by examining performance at both 5 and 9 months of age. Evidence suggests that face processing in infancy is subject to perceptual narrowing, such that infants become more specialized with age. For instance, in some studies, 9-month-olds failed to discriminate between monkeys' faces under conditions in which 6-month-olds did discriminate (Pascalis et al., 2002, 2005; Scott & Monesson, 2009; but see Fair, Flom, Jones, & Martin, 2012). These studies led to the conclusion that a key aspect of perceptual development involves specialization and narrowing, such that, while younger infants are able to process information in a wide variety of stimuli, older infants become specialized on a subset of stimuli with which they have experience (e.g., human faces). This notion of perceptual narrowing, combined with prior studies in which 6-month-olds discriminated between monkey faces but 9-month-olds failed to do so (Pascalis et al., 2002), led to the prediction that 5-month-olds will process second-order spacing changes in monkey faces (and perhaps even in house stimuli) but 9-month-olds will not. We tested this prediction in the current study.

Experiment 1

All studies to date that have examined second-order relational processing in infancy have tested infants' sensitivity to this information only in female faces. It is unknown whether

infants are also sensitive to this information in male faces. This issue is significant because infants as young as 3 months of age prefer to look at female faces over male faces and discriminate between female faces more readily than between male faces (e.g., Quinn et al., 2002; Ramsey et al., 2005; Ramsey-Rennels & Langlois, 2006), at least if the infant had been raised by a female primary care-giver (Quinn et al., 2002). Thus, infants may be more specialized on female faces than on male faces due to the fact that most infants have had more exposure to females than to males. It is possible, therefore, that while infants are sensitive to second-order relational information in female faces, they are not sensitive to the same information in male faces. If so, it would suggest that extensive exposure to a class of stimuli engenders the processing of second-order relational information. Conversely, if infants can detect this information in male faces, it would indicate that extensive experience (to the degree of the typical infant's exposure to female faces) is not necessary to process second-order spatial information.

In Experiment 1, we examined 9-month-olds' sensitivity to second-order relational changes in male faces. The spacing changes tested were similar to the changes in female faces that infants discriminated in a prior study (Hayden et al., 2007). The changes were within the normal range of differences seen in typical population of Caucasian male faces as per Farkas' (1994) norms (see description in the Method section).

We also tested whether 9-month-olds' processing of male face stimuli is subject to an inversion effect by testing separate groups of infants on upright and inverted stimuli. An inversion effect is inferred if performance is superior on upright compared to inverted stimuli (e.g., Bertin & Bhatt, 2004; Cashon & Cohen, 2004; Maurer et al., 2002; Yin, 1969). Inversion effects have been utilized in face processing studies in order to: (a) Rule out performance on the basis of low-level features such as skin tone. If participants discriminate between upright stimuli but not between inverted stimuli, it indicates that performance is not based on low-level image features. (b) Examine participants' knowledge about the canonical orientation of stimuli. If performance is superior on upright than on inverted stimuli, it is inferred that participants have knowledge about the typical orientation of the stimuli. (c) Distinguish between different kinds of processing. Studies have shown that configural processing is more subject to inversion effects than is featural processing; thus, inversion effects have been used to infer configural processing (e.g., Bartlett & Searcy, 1993; Carey & Diamond, 1994; Ferguson, Kulkofsky, Cashon, & Casasola, 2009; Murray, Yong, & Rhodes, 2000). If 9-month-olds in the current experiment exhibit an inversion effect, it would suggest that their performance was based on spatial relational information rather than on low-level image features, and that they are sensitive to the canonical orientation of male faces.

Method

Participants—Participants were 36 9-month-olds (21 females; age range = 257-287 days; mean age = 274.50 days; $SD = 9.27$), predominantly from Caucasian families. They were recruited via birth announcements in the newspaper as well as word of mouth. Data from an additional 2 participants were discarded because of failure to sample both test stimuli.

Stimuli—Color photographs of three male faces were obtained from the MacBrain set (Tottenham et al., 2009; face number 21, 24, and 27). Using Adobe Photoshop, second-order distorted faces were created by moving the eyes apart and the mouth down towards the chin. (Because we do not have permission to publish the photographs used in Experiment 1, we are unable to depict these images in a figure.) These alterations affected the second-order spacing between the eyes and between the nose and the mouth (Bhatt et al., 2005; Hayden et al., 2007; Mondloch et al., 2002). We employed the Farkas (1994) anthropomorphic

averages for male faces to manipulate these second-order relationships within normal parameters. These manipulations were nearly identical to the changes to the female faces in Hayden et al. (2007). In face 1, the eyes were moved approximately 7 mm (.89 degrees) and the mouth 1.5 mm (.19 degrees). According to the Farkas (1994) norms, the manipulations of the eyes and mouth involved 1.66 SD and 0.72 SD changes, respectively. The corresponding values for face 2 was 8.5 mm (1.08 degrees; 1.09 SD) for the eyes, and 2 mm (.26 degrees; 0.57 SD) for the mouth; for face 3, the values were 6 mm (.76 degrees; 2.22 SD) for the eyes, and 3.5 mm (.45 degrees; 1.85 SD) for the mouth. Inverted stimuli in this and subsequent experiments were created by rotating images 180 degrees.

Apparatus—Testing was conducted in a chamber that had floor-to-ceiling black curtains on all sides. The infant was positioned in the center of a seated parent's lap approximately 45 cm in front of a 50-cm computer monitor, which was the sole source of light in the test chamber. The parent was asked to not point or in any way signal to the infant during the procedure (see the General Discussion section for more on this procedure). A video camera located on top of the monitor was used to monitor and record infant's performance for later off-line coding.

Procedure—Infants were tested using a visual paired-comparison procedure similar to those used in many prior studies (e.g., Pascalis et al., 2002, 2005; Scott & Monesson, 2009). They were familiarized to a face until they accumulated 30s of look duration; they were then tested for a preference between this familiar face and a face that differed from it in terms of second-order relations. We chose to use a familiarization procedure rather than an infant-control habituation procedure (in which infants are habituated to a criterion level; see, for example, Bhatt et al., 2005) because prior studies that have compared infants' performance on female versus male faces (Quinn et al., 2002) and on human versus monkey faces (Pascalis et al., 2002) used familiarization procedures.

Each trial began when the infant's attention was directed towards the center of the screen by a rapidly changing shape pattern and the experimenter pressed a button to display the stimuli. During the familiarization trial, two identical copies of a face were presented, one on each side of the monitor. They remained on the screen until the infant accumulated 30s of look duration to the stimuli. The test trial followed immediately, with the familiar face presented on one side and the corresponding face that differed from it in spacing relations presented on the other side. The test trial was terminated after 8s, independent of the infants' behavior (i.e., it was not an accumulated look duration trial). The left/right location of the familiar face pattern was counterbalanced across infants within each condition. We used a single test trial rather than two test trials because pilot testing indicated that novelty preference was not as strong in the second test trial. As in many infant studies, we were trying to utilize the short burst of novelty preference that infants exhibit after familiarization in order to understand stimulus processing, and in our case the single 8s test trial worked best. This duration of testing is comparable to the 10s of testing used in several prior studies (e.g., Pascalis et al. 2002, 2005; Scott & Monesson, 2009). (See the General Discussion section for more on this procedure.)

Infants in the upright condition were familiarized and tested with upright stimuli, while those in the inverted condition saw inverted stimuli throughout. Within each condition, a third of the infants were tested on each of the three faces and its corresponding second-order distorted version. Also, half of the infants within each condition were familiarized to one of the original MacBrain photographs such that the novel face pattern for them was its second-order distorted version; for the other half of the infants, a distorted face was the familiar pattern while its original version was the novel image.

Coding of test trial performance was conducted off-line. The DVD player was slowed to 25% of the normal speed during coding. The coder was blind to the infant's condition and to the left/right position of the novel stimulus. A second experimenter coded data of 10 infants (5 upright and 5 inverted) to assess coding reliability. The Pearson correlation between the two coders' scores was .99.

Results and Discussion

The mean time required to accumulate 30s of looking during familiarization is displayed in Table 1. Infants took longer to be familiarized to the inverted faces compared with the upright faces, $t(34) = 3.30$, $p = .002$, two-tailed, $d = 1.09$, indicating a greater interest in upright faces. Nevertheless, all infants accrued the same total amount of exposure to upright and inverted faces (30s) before being tested.

As in prior studies (e.g., Bhatt et al., 2005; Scott & Monesson, 2009), the dependent measure during the test was preference for the novel face pattern derived by computing the ratio of looking time toward the novel face to overall looking time to both faces (novel and familiar) during the test. This ratio was multiplied by 100 to obtain a percent score (Table 1).

An analysis of outlier status (Tukey, 1977; using SPSS version 20.0) revealed that the score of one infant in the upright condition was an outlier; subsequent analyses were conducted without this score. Infants discriminated second-order changes in the upright but not in the inverted condition (see Table 1). The mean novelty preference score in the upright condition was significantly different from the chance level of 50%, $t(16) = 2.85$, $p = .01$, $d = 1.43$, two-tailed. In contrast, the score in the inverted condition was not different from chance, $t(17) = .45$, $p = .66$. When directly compared, the difference between the scores in the upright versus inverted conditions was not significant, $t(33) = 1.43$, $p = .16$, two-tailed. Given that the direct comparison did not result in a p value less than .05, we used non-parametric tests to examine differences in performance: 15 out of 17 infants in the upright condition exhibited novelty preference (score greater than 50%), whereas only 9 out of 18 infants in the inverted condition did so, $X^2(1, N = 35) = 5.93$, $p = .01$, two-tailed.

Thus, 9-month-olds in Experiment 1 discriminated spacing changes in male faces, indicating that they are sensitive to second-order relational information in male faces. Moreover, as with female faces (e.g., Bhatt et al., 2005), sensitivity was exhibited only when infants were tested with faces in their canonical upright orientation.

Experiment 2

In Experiment 2, we tested 9-month-olds' sensitivity to spacing changes in monkey faces. Prior research suggests that 9-month-olds and adults are specialized on human faces, such that they are superior at discriminating between human faces than between monkey faces (Mondloch et al., 2006; Pascalis et al., 2002, 2005; Scott & Monesson, 2009). Mondloch et al. tested adults and 8-year-olds on a same-different identification task in which the distances between features were manipulated on human and monkey faces. Both adults and children were superior at discriminating spacing changes in human faces than in monkey faces. Pascalis et al. (2002) reported that, after 20s familiarization to faces, 9-month-olds and adults discriminated between human faces but failed to discriminate between monkey faces, although 6-month-olds could discriminate between faces from both categories.

However, no prior study has examined infants' sensitivity to spacing information in monkey faces. In Experiment 2, we examined whether 9-month-olds discriminate spacing changes in monkey faces that were identical to the changes that they discriminated in human male faces

in Experiment 1. Lack of discrimination of second-order changes in monkey faces by 9-month-olds would suggest that differential processing of this kind of information is part of the perceptual specialization process. If, on the other hand, infants are sensitive to second-order relational information in non-human primate faces, then it would indicate that extensive exposure to a particular class of stimuli is not necessary for the processing of second-order relational information in infancy. Although Pascalis et al. (2002, 2005) reported that 9-month-olds do not discriminate between monkey faces, a recent study (Fair et al., 2012) found that increasing the duration of familiarization exposure (from 20s to 40s) leads to discrimination of the same monkey faces that infants failed to discriminate in the Pascalis et al. (2002) study. It was thus an open question as to whether 9-month-olds in Experiment 2 would discriminate spacing changes in monkey faces in the allotted 30s familiarization, a duration that was sufficient for infants to discriminate similar changes in human male faces in Experiment 1.

Method

Participants—Participants were 36 9-month-olds (22 females; age range = 260–286 days; mean age = 275.39 days; $SD = 7.31$), predominantly from Caucasian families. They were recruited in the same manner as infants in Experiment 1.

Stimuli—Stock photographs of three female rhesus macaque monkeys were used in this experiment (Fig. 1). Each monkey face was matched to a corresponding human male face from Experiment 1 in horizontal extent, such that widest distance between the edges of the inner portion of the monkey and human face were the same. It was not possible to match monkey and human faces in both vertical and horizontal extents without distorting features, so we chose to match in terms of horizontal extent because we believed that the horizontal spacing between the eyes was the key spacing change in our study. Also, the spacing changes (in the distance between the eyes and between the nose and the mouth) in each monkey face were matched to the changes made to a corresponding human male face in Experiment 1. As in Experiment 1, half of the infants were familiarized and tested with upright monkey faces while the other half were familiarized and tested with inverted monkey faces (Fig. 1). Counterbalancing of familiar and novel stimuli was also the same as in Experiment 1.

Apparatus and Procedure—The apparatus and procedure were identical to those used in Experiment 1.

Results and Discussion

As in the case of human male faces in Experiment 1, infants accumulated 30s of look duration faster in the upright than in the inverted conditions (see Table 1), $t(34) = 3.46$, $p = .001$, two-tailed, $d = 1.15$. Thus, infants preferred to view monkey faces in their normal orientation, enabling them to accumulate 30s of exposure more rapidly with upright than with inverted stimuli. However, before being tested, infants accumulated the same 30s total duration of exposure to upright and inverted faces.

The novelty preference measure described in Experiment 1 was also employed in the present experiment (Table 1). An outlier analysis conducted as in Experiment 1 did not reveal any outliers. Thus, all infants' scores were included in the final analysis. Infants in the upright condition discriminated spacing changes, but those in the inverted condition did not. Infants' novelty preference score was significantly different from the chance level of 50% in the upright, $t(17) = 3.24$, $p = .004$, two-tailed, $d = 1.57$, but not in the inverted condition, $t(17) = -.92$, $p = .37$. Moreover, the preference score in the upright condition was significantly greater than the score in the inverted condition, $t(34) = 2.92$, $p = .006$, two-tailed, $d = 0.97$.

Also, a species (human, monkey) X orientation (upright, inverted) ANOVA of the combined data from Experiments 1 and 2 revealed only a significant orientation main effect, $F(1,67) = 9.51$, $p = .002$, $\eta_p^2 = .13$. These results suggest that 9-month-olds are similarly sensitive to second-order configural information in monkey and human male faces. Moreover, infants exhibited similar inversion effects with both categories of stimuli, indicating that sensitivity to spacing changes is seen only when the stimuli are in their canonical upright orientation.

The finding that 9-month-olds discriminated between upright monkey faces is noteworthy given that infants this age failed to discriminate between different monkey faces in some previous studies under conditions in which they discriminated between human faces (e.g., Pascalis et al., 2002, 2005; Scott & Monesson, 2009). Pascalis et al. (2002) viewed the species-specific performance at 9 months but not at 6 months as an expression of perceptual narrowing and specialization for the most commonly encountered category of own-species faces. Presumably, the procedure and/or the stimuli used led to the different results in Experiment 2. For instance, in the Pascalis et al. (2002) study, infants accumulated 20s before being tested, while infants in the current experiments accumulated 30s. Such differences may have led to differences in the results. Evidence for this possibility comes from Fair et al. (2012), who found that increasing the duration of familiarization exposure (from 20s to 40s) leads to discrimination of the same monkey faces that infants failed to discriminate in the Pascalis et al. (2002) studies.

Also, while Experiment 2 involved discrimination between unaltered and spatially altered stimuli, the Pascalis et al. (2002) studies involved discrimination between different unaltered monkey faces. Although it is unclear whether this stimulus difference or procedural differences led to the discrepancy in performance between Experiment 2 and Pascalis et al. (2002), we felt that it is important to document whether 9-month-olds discriminate between unaltered monkey faces under the conditions of the current experiment. To this end, we tested an independent group of 9-month-olds ($n = 12$) for discrimination between the three unaltered monkey faces used in Experiment 2. That is, infants were tested for their ability to discriminate one unaltered monkey face from another using the exact same procedure and apparatus used in Experiment 2.

Infants discriminated between the monkey faces: Their mean novelty preference score of 64.42% ($SE = 4.65$) was significantly greater than the chance level of 50%, $t(11) = 3.09$, $p = .01$, two-tailed, $d = 1.86$. Thus, under the conditions of the current experiments, 9-month-olds discriminated between individual monkey faces, thereby failing to exhibit evidence of perceptual specialization shown in some previous studies (Pascalis et al., 2002, 2005; Scott & Monesson, 2009), but being consistent with the results of Experiment 2 and Fair et al. (2012). These findings indicate that specialization and narrowing are not absolute in the sense that the ability to discriminate between faces of other species is lost; rather, procedural issues like the duration of exposure appear to determine infants' processing of other species' faces.

Experiment 3

As noted in the Introduction, adults are less sensitive to spacing information in house stimuli than in faces (Leder & Carbon, 2006; Robbins et al., 2010). This fact, along with other kinds of differences in the processing of faces versus non-face objects, have been used to suggest that faces are "special" for adults (for reviews, see Maurer et al., 2002; McKone & Robbins, 2011). We examined the developmental origins of this specialization in Experiment 3 by testing whether 9-month-olds discriminate spacing changes in house stimuli that were identical to the ones infants discriminated in upright male and monkey faces in Experiments 1 and 2. If 9-month-olds fail to discriminate spacing changes in houses, it would suggest that

the special nature of faces originates early in life. If, on the other hand, infants process spacing changes in house stimuli, it would suggest that specialization, at least as it pertains to second-order relational processing, takes longer to develop than 9 months of age.

Infants in Experiment 3 were tested with house stimuli of the sort shown in Figure 2. These stimuli were matched to the face stimuli used in Experiment 1 in terms of their overall size, the size of the features, and the location of the features, such that the original spacing between features and the changes in these spaces in the second-order distorted versions were exactly the same in the house stimuli as in the face stimuli. If, despite this equivalence with face stimuli, infants fail to process spacing changes in house stimuli, then it would be evidence that infants more readily process configural spacing information in faces than in houses.

Method

Participants—Participants were 24 9-month-olds (11 females; age range = 256–284 days; mean age = 273.13 days; $SD = 8.86$), predominantly from Caucasian families. They were recruited in the same manner as the infants in previous experiments. Data from an additional participant were discarded because of sibling interference.

Stimuli—The stimuli were house images that were matched to the three upright human face images used in Experiment 1. Each house pattern was matched to a corresponding face pattern such that its overall size and the size of its features (width and height), the overall configuration of the features, and space between the features was the same. The windows were matched to the eyes, the door to the nose, and the steps to the mouth; also, the alteration of the spacing between features in the second-order distorted versions of these stimuli was exactly the same in houses as in the faces (see Fig. 2). For each face, two different corresponding house stimuli were created: they differed in how far the top of the door extended. This is because there is variation between faces in how prominent the nose is in between the eyes: in some cases, the area between the eyes is flat, whereas in other cases the nose extends into the area between the eyes. We sought to capture this difference by using two different versions of matching of house features to faces. In one case, the top of the door extended to the middle of the space in between the windows (Figures 2A and 2B), corresponding to a nose that is visible between the eyes. In the other case, the top of the door stopped below the windows (Figures 2C and 2D), corresponding to a nose that ends below the level of the eyes.

Counterbalancing was the same in Experiment 3 as in Experiments 1 and 2. Within each pair of houses, each house was equally often a novel and familiar stimulus. Also, for half of the infants, the novel house was presented on the left during the test trial; for the other half, the novel face was presented on the right. Moreover, half of the infants were familiarized and tested with the short-door version of houses and the other infants were familiarized and tested with the long-door version of houses.

Apparatus and Procedure—The apparatus and procedure were the same as those used in Experiments 1 and 2.

Results and Discussion

Preliminary analyses revealed that there was no difference in performance in the long-door versus short-door condition. Thus, data from the two conditions are combined in the following analyses. The time required for infants to accumulate the 30s familiarization to the house stimuli is shown in Table 1. It took longer for infants to accumulate 30s of look duration to the house stimuli than to the upright human male face stimuli in Experiment 1,

$t(40) = 4.44, p < .001$, two-tailed, $d = 1.40$, and to the upright monkey face stimuli in Experiment 2, $t(40) = 4.51, p < .001$, two-tailed, $d = 1.43$. Thus, the face stimuli used in Experiments 1 and 2 led to more sustained looking by infants than the house stimuli in the current experiment, although infants accumulated 30s total duration of exposure before being tested in all cases.

An outlier analysis of the test data conducted as in previous experiments revealed that the score of one infant was an outlier. The following analyses were conducted without this score. Infants failed to discriminate changes in the spacing in house stimuli. Their mean novelty preference score was not significantly different from the chance level of 50%, $t(22) = .48, p = .63$. Only 12 out of 23 infants had a score that was greater than 50% (binomial probability $p = .66$). Moreover, pre-planned tests revealed that the novelty preference score on house stimuli was marginally significantly less than the score on upright monkey faces in Experiment 2, $t(39) = 2.01, p = .05$, two-tailed, $d = 0.63$, but not significantly different from the score on upright human male face stimuli in Experiment 1, $t(38) = 1.53, p = .13$, two-tailed. However, note that when additional data from infants tested on human face and house stimuli in Experiment 4 (see below) were combined with those of infants in the current experiment, an ANOVA revealed a statistically significant difference between scores on house versus male face stimuli.

The results suggest that 9-month-olds failed to discriminate changes in the house stimuli even though the spacing relations and changes were the same in these stimuli as in the face stimuli used in Experiment 1. Thus, 9-month-olds exhibited specialization: they failed to process the same information in house stimuli that they processed in face stimuli. This finding indicates that the special nature of faces originates in infancy and is reflected in the superior processing of configural information in faces than in non-face stimuli.

Experiment 4

Experiments 1-3 revealed that 9-month-olds are more likely to process configural information in faces than in houses. One question that follows is whether this specialization is evident even earlier in life. We tested 5-month-olds in Experiment 4 to examine this issue. We chose to study 5-month-olds because this is the youngest age at which there is clear evidence of discrimination of second-order spacing changes within the range seen in typical populations (Bhatt et al., 2005; Hayden et al., 2007).

As discussed earlier, prior research suggests that the development of face processing follows a perceptual narrowing process. For example, 6-month-olds discriminated between monkey faces in Pascalis et al. (2002) but 9-month-olds failed to do so. It is possible, therefore, that 5-month-olds would discriminate spacing changes in house stimuli under conditions in which 9-month-olds failed. If so, it would suggest that perceptual narrowing occurs between 5 and 9 months of age and results in more specialized configural processing in faces than in non-face stimuli by the older age. Alternatively, 5-month-olds might fail to discriminate spacing changes not only in house stimuli but also in face stimuli because of limited (or no) exposure to the non-female face categories that were tested in this study. Combined with prior findings indicating that 5-month-olds are sensitive to similar spacing changes in female faces (Hayden et al., 2007), the latter pattern of results would suggest that the ability to generalize discrimination to novel categories of stimuli is enhanced from 5 to 9 months of age. A third possibility is that 5-month-olds would show a similar pattern of results as 9-month-olds, in which case it would indicate that neither perceptual narrowing nor changes in generalization ability are evident from 5 to 9 months.

One group of 5-month-olds was tested on the house stimuli used in Experiment 3. Another group was tested on upright monkey stimuli used in Experiment 2, while a third group of

infants was tested on the inverted monkey stimuli used in Experiment 2. Infants were not tested on human male faces because, as described below, they exhibited sensitivity to spacing changes in upright monkey faces, and it is unlikely that 5-month-olds would be sensitive to spacing changes in monkey faces but not in human male faces.

Method

Participants—Participants were 60 5-month-olds (37 females; age range = 140-160 days; mean age = 150.41 days; $SD = 6.12$), predominantly from Caucasian families. They were recruited in the same manner as infants in previous experiments. Data from 9 participants were discarded because of failure to sample both test stimuli ($n = 8$) and for crying ($n = 1$).

Apparatus and Procedure—The procedure used to test infants was the same as that used in Experiments 1-3, with one exception. As in Experiments 1-3, parents were instructed to not do anything that might influence infants' looking, but in this study we also had the parents wear dark glasses that prevented them from viewing the stimuli. This provided additional confidence that infants' looking was not influenced by the parents.

Results and Discussion

House Stimuli—As in the case of 9-month-olds in Experiment 3, preliminary analyses revealed no difference in performance on the long-door versus short-door conditions. Thus, data from the two conditions were combined in the following analyses. The time required for infants to accumulate the 30s familiarization to the house stimuli is shown in Table 1. This time did not differ from the time required by 9-month-olds, $t(45) = 0.16$, $p = .87$.

An outlier analysis of the test scores conducted as in Experiments 1-3 did not reveal any outliers. Like 9-month-olds, 5-month-olds failed to discriminate spacing changes in house stimuli. Their mean novelty preference score (see Table 1) did not differ from the chance level of 50%. Only 12 out of 24 participants had a novelty preference score that was greater than 50%, binomial probability $p = .58$. Moreover, the 5-month-olds' score did not differ significantly from that of 9-month-olds in Experiment 3, $t(45) = 0.27$, $p = .78$.

Monkey Faces—The times required for 5-month-olds in the upright and inverted conditions to accumulate 30s of total look duration is shown in Table 1. The difference between the times was not statistically significant, $t(33) = 1.17$, $p = .25$.

An outlier analysis of the test scores revealed that the score of one infant in the upright condition was an outlier. This score was discarded in the following analyses. Five-month-olds' discriminated spacing changes in upright monkey faces but failed to discriminate the same changes in inverted faces. Their mean score on upright faces was significantly different from the chance level of 50%, $t(16) = 2.84$, $p = .01$, two-tailed, $d = 1.42$, but their score in the inverted condition was not, $t(17) = .08$, $p = .93$. Comparison of 5-month-olds' scores on monkey faces in relation to 9-month-olds' performance in Experiment 2 using an age (5 months, 9 months) X orientation (upright, inverted) ANOVA revealed only a significant effect of orientation, $F(1, 79) = 12.95$, $p = .001$, $\eta_p^2 = .14$. Neither the age main effect nor the interaction was significant, both p s $> .55$. These results suggest that there was no evidence to indicate differences in performance between 5- and 9-month-olds, with both groups discriminating spacing changes in upright monkey faces but not in inverted monkey faces.

Moreover, a comparison of 5- and 9-month-olds' performance on houses and upright monkey faces, using an age (5 months, 9 months) X stimulus (monkey, house) ANOVA revealed a significant effect of stimulus, $F(1, 78) = 5.21$, $p = .02$, $\eta_p^2 = .06$. Neither the age

main effect nor the interaction was significant, both p s > .80. Thus, both 5- and 9-month-olds exhibited a similar difference in performance on upright monkey face versus house stimuli, discriminating spacing changes in the former but not in the latter.

In totality, the results from Experiment 4 failed to reveal any difference in performance at 5 versus 9 months of age. Like 9-month-olds, 5-month-olds discriminated second-order spacing changes in upright monkey faces but not in houses or in inverted faces. In particular, the fact that both 5- and 9-month-olds performed similarly on monkey faces is inconsistent with reports of perceptual narrowing and increased specialization over this age range (Pascalis et al., 2002, 2005; Scott & Monesson, 2009).

General Discussion

The processing of second-order spacing relations among features is thought to contribute to expert face processing by adults. The current study demonstrates that 5- and 9-month-old infants are more sensitive to this information in human and non-human primate faces than in house stimuli. This finding is consistent with adults' superior processing of spacing information in faces than in house stimuli (Leder & Carbon, 2006; Robbins et al., 2010), and indicates that perceptual specialization for face stimuli and the contribution of configural spacing information to this specialization are evident at least to some extent by 5 months of age. However, unlike some prior studies (Pascalis et al., 2002, 2005; Scott & Monesson, 2009), we did not find evidence of perceptual narrowing in the current study: 9-month-olds' discriminated between monkey faces and performed similarly to 5-month-olds.

The current results extend prior findings which indicated that infants are sensitive to second-order relational information in human female faces (e.g., Bhatt et al., 2005; Hayden et al., 2007; Quinn & Tanaka, 2009). Prior research suggests differences in the general processing of human female versus male faces (e.g., Quinn et al., 2002; Ramsey et al., 2005) and human versus monkey faces (Pascalis et al., 2002). The association of second-order relational information processing with expertise in the adult literature (e.g., Rotstein, Geng, Driver, & Dolan, 2007) suggests that differences in the processing of these various kinds of stimuli by infants would manifest itself in the processing of second-order information in these stimuli. However, our findings are not consistent with this account. Infants detected spacing changes in human male and monkey faces that were comparable to those detected in female faces. The fact that infants have little or no exposure to monkey faces yet performed similarly on both male and monkey faces suggests that direct exposure is not a prerequisite for the ability to process second-order information, and gives credence to the idea that the similarity of male faces and monkey faces to female faces led to a similar type of processing (also see Sugita, 2008).

It is also significant that infants in the current experiments exhibited similar inversion effects on human male and monkey faces. Generally, adults exhibit a greater degree of inversion effects on categories of stimuli to which they have a great deal of exposure (Diamond & Carey, 1986; Yin, 1969). However, even monkey faces were subject to similar inversion effects as human faces at both 5 and 9 months of age in the current experiments. Given the typical infants' lack of exposure to monkey faces, the current findings thus suggest that inversion effects are not necessarily limited by lack of familiarity. It is likely that the similarity of monkey faces to human faces led to similar kinds of processing and resulted in similar inversion effects.

The fact that, unlike adults in some studies (e.g., Mondloch et al., 2006; Pascalis et al., 2002), infants in the current experiments failed to exhibit differences in the processing of monkey versus human faces might indicate that specialization for human faces is not as developed in infants as in adults. Alternatively, it is possible that the procedures and stimuli

used in the current experiments were not sufficient to elicit differences in performance across species. Smaller and/or more difficult to detect second-order relational changes could reveal differences in performance between monkey and human faces. Conversely, easier tasks involving greater changes in spacing and/or procedural changes such as longer familiarization durations might enable infants to discriminate changes even in house stimuli. In other words, the lack of differences between human versus monkey faces and the differences between faces versus houses obtained in the current study may not reflect qualitative differences (or lack thereof) in the capacity to discriminate spacing changes in various stimuli. Furthermore, although an attempt was made to equate changes in house stimuli to those in the face stimuli, there are a variety of differences between the different classes of stimuli (such as dissimilar outer shapes), and this may have led to differences in performance. Thus, the current results should not be construed to mean that infants are incapable of discriminating spacing changes in house stimuli or always perform in exactly the same way on monkey and human faces under all conditions.

One issue that was not addressed in the current study concerns the processing of other kinds of information besides second-order relational information in faces and houses. For instance, infants might also show differences in the processing of featural information from different categories of stimuli. If so, it would indicate that the kind of performance differences on face stimuli versus house stimuli exhibited in the current research is not specific to second-order relational information. Alternatively, it is possible that differences are evident only in the case of second-order relational processing, which would mean that second-order relational processing underlies general differences in performance on categories of stimuli. Future research will have to examine these possibilities. A complete understanding of the development of face processing specialization will require the examination of the processing of many different kinds of information from faces and non-face stimuli under a variety of procedural and stimulus conditions.

The current results also have implications for perceptual narrowing. Consistent with the findings of Fair et al. (2012) with 12-month-olds, 9-month-old infants in Experiment 2 (and in the discrimination study reported in the Results and Discussion section of Experiment 2) discriminated between monkey faces. Moreover, there was no change in performance on monkey faces between 5 and 9 months of age in the current experiments (see Experiments 2 and 4). This is in contrast to some studies in which 6-month-olds discriminated between monkey faces but 9-month-olds did not (Pascalis et al., 2002, 2005; Scott & Monesson, 2009). The latter studies have been thought to indicate perceptual narrowing similar to that seen in the speech (e.g., Werker & Tees, 1984) and intersensory matching domains (e.g., Lewkowicz & Ghazanfar, 2006). The fact that there was no evidence to indicate perceptual narrowing between 5 and 9 months of age in the current experiments indicates that procedural and stimulus factors play a role in whether or not infants demonstrate perceptual narrowing. This conclusion is consistent with other reports in the literature. For instance, although Pascalis et al. (2002) found that human adults do not discriminate between monkey faces, Mondloch et al. (2006), using a different task, found that adults discriminate second-order relations in the same faces (although not as well as in human faces). These findings indicate that perceptual narrowing does not necessarily indicate the loss of the ability to discriminate. Rather, even older infants and adults are able to discriminate between faces of other species under different circumstances than the ones used in the original studies that indicated perceptual narrowing. Thus, as noted by Fair et al. (2012), perceptual narrowing is not an absolute loss of discrimination capacity but reflects a flexible perceptual system that responds to particular circumstances such that, under some conditions, older infants and adults fail to discriminate between stimuli while younger infants do.

A limitation of the current study is that infants were tested on only one 8s test trial. Although some prior infant studies have also utilized only one test trial (e.g., Feigenson, Carey, & Hauser, 2002; Hertenstein & Campos, 2004; Surian, Caldi, & Sperber, 2007), most studies have used two or more test trials. As noted earlier, our use of a single test trial was driven by the fact that pilot testing indicated that performance was much stronger in the first trial than in the second trial. Novelty preference procedures of the kind used in the current experiments use a quick and short-lived burst of differential responding to novel stimuli to infer discrimination (Quinn & Intraub, 2007), and we utilized this tendency of infants in the current experiments. It is not clear why infants' performance was stable only in the first trial but similar findings of performance differences between two test trials have been reported by Scott & Nelson (2006), who also studied infants' perception of spacing changes. We have confidence in our findings because of the systematic nature of the results and replication of the findings across different ages (5 and 9 months). Moreover, although the use of only one trial precluded the possibility of checking side-bias, performance cannot be attributed to any left/right bias on the part of infants at the group level due to the fact that the position of the novel/familiar stimuli were counterbalanced across infants.

Another methodological issue concerns the fact that infants were seated on a parent's lap while being tested. In this respect, we followed a common practice in the infancy literature (e.g., Corrow, Granrud, Mathison, & Yonas, 2012; Farroni, Menon, Rigato, & Johnson, 2007; Needham & Kaufman, 1997; Repacholi & Meltzoff, 2007). The parents were asked to not point or to signal anything to the infants. Nevertheless, one can question whether infants' performance could have been influenced by the parent. We do not believe that is the case because all stimuli (both inverted and upright) had differences that were above threshold levels for adults. Thus, it is very unlikely that they would have affected performance in different ways in different conditions (i.e., leading to discrimination with some stimuli and lack of discrimination in other cases). Moreover, 5-month-olds' performance was similar to that of 9-month-olds', although in their case the parents wore dark glasses that prevented them from seeing the stimuli. Furthermore, we tested a small group of 9-month-olds with their parents wearing opaque dark glasses. This group ($n = 6$) was tested on the individual monkey discrimination task which contradicted prior results from Pascalis et al. (2002) findings (see Results and Discussion section of Experiment 2). Infants discriminated between monkey faces in this small replication study: their performance was similar to that of the group tested without dark glasses, with a mean novelty preference score of 57.86% ($SE = 2.80$), $t(5) = 2.80$, $p = .03$, two-tailed, $d = 2.50$. Moreover, all infants exhibited novelty preference scores that were greater than 50%. This suggests that our original finding of 9-month-olds' discrimination between monkey faces is reliable and not affected by whether or not parents are able to view the stimuli.

In summary, the current research demonstrates that, early in life, infants encode secondorder relational information that is thought to underlie face processing specialization in adulthood. Infants' sensitivity to this information extends to classes of stimuli with which they are likely to have had very little contact, indicating that direct exposure is not the only means of specialized processing of a class of objects. However, infants' sensitivity to configural information in the current study was confined to human and monkey faces and did not extend to non-face objects. This suggests that specialization for faces early in life is at least partly driven by the greater propensity to use configural spacing information in this class of stimuli. Additionally, the results did not indicate any changes in specialization from 5 to 9 months of age, suggesting that the perceptual narrowing that has been thought to occur over this age range is not absolute in the sense that the ability to discriminate between other species' faces is lost at older ages. Rather, the perceptual system appears to function differently under different conditions, and this flexibility interacts with age.

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References

- Bartlett J, Searcy J. Inversion and configuration of faces. *Cognitive Psychology*. 1993; 25:281–316. [PubMed: 8354050]
- Bertin E, Bhatt RS. The Thatcher illusion and face processing in infancy. *Developmental Science*. 2004; 7:431–436. [PubMed: 15484591]
- Bhatt RS, Bertin E, Hayden A, Reed A. Face processing in infancy: Developmental changes in the use of different kinds of relational information. *Child Development*. 2005; 76:169–181. [PubMed: 15693765]
- Carey S, Diamond R. Are faces perceived as configurations more by adults than by children? *Visual Cognition*. 1994; 1(2/3):253–274.
- Carrow S, Granrud CE, Mathison J, Yonas A. Infants and adults use line junction information to perceive 3D shape. *Journal of Vision*. 2012; 12(1):1–7.
- Cashon CH, Cohen LB. Beyond U-shaped development in infants' processing of faces: An information-processing account. *Journal of Cognition and Development*. 2004; 5:59–80.
- Diamond R, Carey S. Why faces are and are not special: An effect of expertise. *Journal of Experimental Psychology: General*. 1986; 115(2):107–117. [PubMed: 2940312]
- Fair J, Flom R, Jones J, Martin J. Perceptual learning: 12-month-olds' discrimination of monkey faces. *Child Development*. 2012; 83(6):1996–2006. [PubMed: 22803582]
- Farkas, LG. *Anthropometry of the head and face in medicine*. 2. New York: Elsevier; 1994.
- Farroni T, Menon E, Rigato S, Johnson MH. The perception of facial expressions in newborns. *European Journal of Developmental Psychology*. 2007; 4(1):2–13. [PubMed: 20228970]
- Feigenson L, Carey S, Hauser M. The representations underlying infants' choice of more: Object files versus analog magnitudes. *Psychological Science*. 2002; 13(2):150–156. [PubMed: 11933999]
- Ferguson KT, Kulkofsky S, Cashon CH, Casasola M. The development of specialized processing of own-race faces in infancy. *Infancy*. 2009; 14(3):263–284.
- Hayden A, Bhatt RS, Reed A, Corbly CR, Joseph JE. The development of expert face processing: Are infants sensitive to normal differences in second-order relational information? *Journal of Experimental Child Psychology*. 2007; 97:85–98. [PubMed: 17339043]
- Hertenstein MJ, Campos JJ. The retention effects of an adult's emotional displays on infant behavior. *Child Development*. 2004; 75(2):595–613. [PubMed: 15056208]
- Leder H, Carbon CC. Face-specific configural processing of relational information. *British Journal of Psychology*. 2006; 97:19–29. [PubMed: 16464285]
- Lewkowicz DJ, Ghazanfar AA. The decline of cross-species intersensory perception in human infants. *Proceedings of the National Academy of Sciences of the United States of America*. 2006; 103(17):6771–6774. [PubMed: 16618919]
- Maurer D, LeGrand R, Mondloch C. The many faces of configural processing. *TRENDS in cognitive sciences*. 2002; 6:255–260. [PubMed: 12039607]
- McKone, E.; Robbins, R. Are faces special?. In: Calder, AJ.; Rhodes, G.; Haxby, JV.; Johnson, MH., editors. *Oxford handbook of face perception*. Oxford University Press; 2011. p. 149-176.
- Mondloch, CJ.; Le Grand, R.; Maurer, D. Development of expertise in face recognition. In: Gauthier, I.; Tarr, MJ.; Bub, D., editors. *Perceptual expertise: Bridging brain and behavior*. Oxford University Press; 2010. p. 67-106.
- Mondloch CJ, Maurer D, Ahola S. Becoming a face expert. *Psychological Science*. 2006; 17(11):930–934. [PubMed: 17176421]
- Murray JE, Yong E, Rhodes G. Revisiting the perception of upside-down faces. *Psychological Science*. 2000; 11(6):492–496. [PubMed: 11202495]
- Needham A, Kaufman J. Infants' integration of information from different sources in object segregation. *Early Development and Parenting*. 1997; 6:137–147.

- Pascalis O, de Hann M, Nelson CA. Is face processing species-specific during the first year of life? *Science*. 2002; 296:1321–1323. [PubMed: 12016317]
- Pascalis O, Scott LS, Kelly DJ, Shannon RW, Nicholson E, Coleman M, Nelson CA. Plasticity of face processing in infancy. *Proceedings of the National Academy of Sciences, USA*. 2005; 102:5297–5300.
- Quinn PC, Intraub H. Perceiving “outside the box” occurs early in development: Evidence for boundary extension in three-to seven-month-old infants. *Child Development*. 2007; 78(1):324–334. [PubMed: 17328708]
- Quinn PC, Tanaka JW. Infants’ processing of featural and configural information in the upper and lower halves of the face. *Infancy*. 2009; 14(4):474–487.
- Quinn PC, Yahr J, Kuhn A, Slater AM, Pascalis O. Representation of the gender of human faces by infants: a preference for female. *Perception*. 2002; 31:1109–1121. [PubMed: 12375875]
- Ramsey JL, Langlois JH, Marti NC. Infant categorization of faces: ladies first. *Developmental Review*. 2005; 25:212–246.
- Ramsey-Rennels JL, Langlois JH. Infants’ differential processing of female and male faces. *Current Directions in Psychological Science*. 2006; 15:59–62.
- Rennels JL, Davis RE. Facial experience during the first year. *Infant Behavior and Development*. 2008; 31:665–678. [PubMed: 18554724]
- Repacholi BM, Meltzoff AN. Emotional eavesdropping: Infants selectively respond to indirect emotional signals. *Child Development*. 2007; 78(2):503–521. [PubMed: 17381787]
- Robbins RA, Nishimura M, Mondloch CJ, Lewis TL, Maurer D. Deficits in sensitivity to spacing after early visual deprivation in humans: A comparison of human faces, monkey faces, and houses. *Developmental Psychobiology*. 2010; 52:775–781. [PubMed: 20564328]
- Rotshtein P, Geng JJ, Driver J, Dolan RJ. Role of features and second-order relations in face discrimination, face recognition, and individual face skills: Behavioral and functional magnetic resonance imaging data. *Journal of Cognitive Neuroscience*. 2007; 19:1435–1452. [PubMed: 17714006]
- Scott LS, Monesson A. The origin of biases in face perception. *Psychological Science*. 2009; 20:676–680. [PubMed: 19422630]
- Scott LS, Nelson CA. Featural and configural face processing in adults and infants: A behavioral and electrophysiological investigation. *Perception*. 2006; 35:1107–1128. [PubMed: 17076069]
- Sugita Y. Face perception in monkeys reared with no exposure to faces. *Proceedings of the National Academy of Sciences*. 2008; 105:394–398.
- Surian L, Calid S, Sperber D. Attribution of beliefs by 13-month-old infants. *Psychological Science*. 2007; 18(7):580–586. [PubMed: 17614865]
- Thompson LA, Madrid V, Westbrook S, Johnston V. Infants attend to second-order relational properties of faces. *Psychonomic Bulletin & Review*. 2001; 8:769–777. [PubMed: 11848598]
- Tottenham N, Tanaka JW, Leon AC, McCarry T, Nurse M, et al. The NimStim set of facial expressions: judgments from untrained research participants. *Psychiatry Research*. 2009; 168:242–249. [PubMed: 19564050]
- Tukey, JW. *Exploratory data analysis*. Menlo Park, CA: Addison-Wesley; 1977.
- Werker JF, Tees RC. Cross-language speech perception: Evidence for perceptual reorganization during the first year of life. *Infant Behavior and Development*. 1984; 7:49–63.
- Yin RK. Looking at upside-down faces. *Journal of Experimental Psychology*. 1969; 81:141–145.

- Configural spacing information contributes to face processing expertise in adults
- 5- and 9-month-olds discriminated spacing changes in human male and monkey faces
- However, infants failed to discriminate matched changes in house stimuli
- Thus, infants exhibited specialization on primate face stimuli
- Perceptual narrowing in face processing was not evident in this study

Distorted Monkey Face Normal Monkey Face

Figure 1.

An example of the monkey faces that infants viewed in Experiment 2. Second-order relational information was manipulated by increasing the space between the eyes and between the nose and the mouth to the same extent as in the human male faces used in Experiment 1. Infants in the upright condition were familiarized and tested with upright monkey faces, whereas those in the inverted condition were familiarized and tested with the same stimuli inverted.

(A) Distorted House Face **(B) Normal House Face** **(C) Distorted House Face** **(D) Normal House Face****Figure 2.**

Examples of the house stimuli used in Experiment 4. Figures 2A and 2B represent examples of houses with long doors and their distorted versions; Figures 2C and 2D represent houses with short doors. The original space between features and the changes in them were the same in the house stimuli as in the face stimuli. This was accomplished by matching the house stimuli to the human male faces in Experiment 1 in terms of overall size, the size of the features, and the location of the features. The windows were matched to eyes, the door to the nose (in two ways, see text for details), and the steps to the mouth.

Mean (and Standard Error) of Time to Accumulate 30s of Familiarization Duration and Percent Preference for the Novel Stimulus

Table 1

TIME TO ACCUMULATE 30s OF FAMILIARIZATION		PREFERENCE FOR NOVEL STIMULUS DURING TEST		
N		M (SE)	t	p (two-tailed)
Experiment 1: 9-month-olds on Human Male Faces				
Upright	17 30.31 (.24)	58.84 (3.10)	2.85 *	.01
Inverted	18 33.27 (.86)	51.71 (3.84)	0.45	.66
Experiment 2: 9-month-olds on Monkey faces				
Upright	18 30.15 (.15)	61.43 (3.52)	3.24 *	.004
Inverted	18 35.37 (1.50)	46.65 (3.64)	-0.92	.37
Experiment 3: 9-month-olds on Houses				
Upright	23 40.84 (2.04)	51.62 (3.33)	0.48	.63
Experiment 4: 5-month-olds on Houses				
Upright	24 40.92 (2.12)	53.15 (4.59)	0.68	.50
5-month-olds on Monkeys				
Upright	17 32.89 (1.23)	61.90 (4.19)	2.84 *	.01
Inverted	18 37.34 (3.52)	50.42 (4.79)	0.08	.93

* $p < .05$, two-tailed; significantly different from the chance level of 50%