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Visual Scanning of Males and Females in Infancy

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Abstract

This study addressed the development of attention to information that is socially relevant to adults by examining infants' ($n = 64$) scanning patterns of male and female bodies. Infants exhibited systematic attention to regions associated with sex-related scanning by adults, with 3.5- and 6.5-month-olds looking longer at the torso of females than males and longer at the legs of males than females. However, this pattern of looking was not found when infants were tested on headless bodies in Experiment 2, which suggests that infants' differential gaze pattern in Experiment 1 was not due to low-level stimulus features, such as clothing, and also indicates that facial/head information is necessary for infants to exhibit sex-specific scanning. We discuss implications for models of face and body knowledge development.

Keywords

sex perception in infancy; social information processing; visual scanning; attention; body knowledge in infancy

Given the societal importance of sex, it is no surprise that adults are experts at sex classifications. Adults are able to utilize subtle cues such as gait and waist-to-hip ratios to efficiently discriminate males from females (Johnson, 2004). They are also able to distinguish between males and females from greatly impoverished stimuli, such as point light displays of walking figures (Johnson & Tassinari, 2005). Expert processing of the sexes by adults is further reflected in their differential allocation of attention to critical regions of male and female bodies. In particular, as described below, the breast region of females and the leg/pelvic region of males seem to be particular sex-specific features that adults scan systematically.

The purpose of the current study was to determine whether infants' attention to specific body regions also differs depending on the sex of the stimulus, and whether this kind of specific scanning is dependent on cues from the face/head. Sex dependent scanning patterns would indicate that infants are sensitive to sex information and systematically attend to this information in bodies. Such a finding would demonstrate that socially relevant cues are not

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only discerned very early in life, but also drive how infants seek information in their environment. Moreover, the examination of the role of facial information in body scanning will inform us about the relationship between body and face knowledge development.

Sex-specific Scanning Patterns in Adults

Hewig, Trippe, Hecht, Straube, and Miltner (2008) exposed adults to photographs of 15 female and 15 male adult models. Particular body features eliciting differences in scanning were found to be the breasts of females and legs of males. Moreover, scanning was affected by the sex of the observer, such that males attended more to female torsos, while females attended more to male legs. Similarly, Nummenmaa, Hietanen, Santtila, and Hyönä, (2012) exposed heterosexual male and female participants to photographs of clothed and nude males and females. The photographs were truncated below the pelvic region and did not show the legs fully. Both men and women looked longer at the breast area of female than male images. Women looked longer at the pelvic/leg area of males than females, whereas males looked equally long at male and female pelvic/leg regions. Overall, these studies indicate that the breast and leg/pelvic region of images are significant regions of sex-specific scanning by adults.

Scanning Patterns in Infancy

One can imagine the difficult task infants have in choosing what information to attend to in any given stimulus. Starting from birth, infants are presented with an overwhelming amount of sensory information and are in need of rules to guide their attention in efficient ways. There is evidence indicating that infants attend to visual information in a systematic manner. For example, Bronson (1994) examined 6- to 13-week-olds' scanning patterns of static geometric figures and found that 13-week-old infants appear to scan images in intentional ways, including increased between-figure comparisons relative to the younger participants. More evidence of systematic looking in infancy comes from Wilcox, Stubbs, Wheeler, and Alexander's (2013) study of infants' scanning of talking human faces. They reported a developmental difference, finding that 9-month-olds allocated more attention to the eye region than to the mouth region, whereas 3- to 4-month-olds exhibited more equally distributed scanning patterns (also see Lewkowicz & Hansen-Tift, 2012). This work illustrates early developmental changes in systematic scanning patterns of social stimuli. Furthermore, Kovack-Lesh, McMurray, and Oakes (2014) found that 4-month-olds differed in their scanning patterns of cat and dog images depending on their experience with pets. This finding is a clear example of how knowledge based on experience can engender distinct scanning patterns.

Infants also alter their looking patterns based on the category membership of the stimulus being presented. For example, 5-month-olds look longer at fearful faces relative to a distractor compared to happy and neutral faces (Heck, Hock, White, Jubran, & Bhatt, 2016). Additionally, infants demonstrate differential scanning patterns of own- compared to other-race faces (Xiao, Quinn, Pascalis, & Lee, 2014). However, unlike this kind of research with faces, to our knowledge, no study has focused on infants' visual attention to body parts as a function of social factors such as sex. This was the issue addressed in the current study.

Sensitivity to Sex Information in Infancy

Given the importance of sex information for social interactions, it is not surprising that infants appear to be sensitive to differences between the sexes early in life. Infants' experiences with males and females are likely to differ prior to and immediately following birth (e.g., increased exposure to a female's voice prenatally; breast feeding by a female caregiver). Such biased exposure likely leads to differential processing of males versus females. For example, asymmetries have been found in infants' categorization of female versus male faces, such that infants are able to form prototypical averages or aggregates from multiple exemplars of female faces (de Haan, Johnson, Maurer & Perrett, 2001; Rubenstein et al., 1999), but not male faces (Ramsey, Langlois, & Marti, 2005). Also, 3- to 4-month-old infants with female caregivers prefer to look at female faces over male faces (Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002). Furthermore, an ERP study documented larger N290 amplitudes when 7-month-old infants were exposed to images of female faces as opposed to male faces, as well as a priming effect (evidenced by a significantly more negative N290 amplitude-indicative of novelty) when comparing novel versus familiar images of female faces but not male faces (Righi, Westerlund, Congdon, Troller-Renfree, & Nelson, 2014). These findings provide additional evidence that female and male faces are processed differently by young infants.

Moreover, infants succeed in intermodal matching tasks involving sex information. Walker-Andrews, Bahrick, Raglioni, and Diaz (1991) presented a male or a female voice while simultaneously showing videos of male and females faces. Six-month-old infants associated faces and voices based on sex by looking longer at the matching video, whereas 3.5- and 4-month-olds showed no reliable evidence of matching across modalities. While other studies (e.g., Hillairt de Boisferon et al., 2015) differ in the ages at which infants integrate facial information and vocal cues, the results suggest that infants are sensitive to sex category information within the first year of life.

Unlike the research on sex information with faces and voices, little has been done to examine infants' sensitivity to sex information in bodies. However, one study found that infants respond to sex mismatches between faces and bodies (e.g., a female head paired with a male body) as early as 5 months of age (Hock, Kangas, Zieber, & Bhatt, 2015). Furthermore, Alexander, Hawkins, Wilcox, and Hirshkowitz (2016) found that infants, 3-18 months of age, prefer to attend to images of female bodies compared to male bodies. However, to our knowledge, no study has examined whether infants scan portions of male and female bodies differently, which was the issue addressed in the current study.

Body Knowledge Development in Infancy

Some early research suggested that that knowledge about bodies is a function of a general learning mechanism and that robust knowledge is not present until the second year of life (Slaughter, Heron-Delaney, & Christie, 2012). However, there is a growing body of work demonstrating that at least some aspects of body knowledge are evident early in life (Bhatt, Hock, White, Jubran, & Galati, 2016). For example, by 3.5 months of age, infants exhibit knowledge of the structure of bodies both in terms of body part locations and body part

proportions (Gliga & Dehaene-Lambertz, 2005; Zieber, Kangas, Hock, & Bhatt, 2015). Additionally, 5-month-olds process bodies holistically, as evidenced by an ability to discriminate between body postures when images of whole bodies are presented but not when only the body parts are presented in isolation or in the context of a scrambled body (Hock, White, Jubran, & Bhatt, 2016).

Infants have also been found to be sensitive to social information, such as emotion, in bodies. Furthermore, this knowledge rapidly develops in the first half of the first year of life as 6.5-month-olds, but not 3.5-month-olds, were found to match emotional vocalizations to corresponding displays of both static and dynamic displays of emotional bodies (e.g., fists clenched for anger or cowering for fear; Zieber, Kangas, Hock, & Bhatt, 2014a, 2014b; also see Missana, Rajhans, Atkinson, & Grossmann, 2014).

Such evidence of knowledge about structural and social information in bodies early in life has lead researchers to postulate that body and face knowledge may have more similar developmental trajectories than research originally suggested (Bhatt et al., 2016). One proposed mechanism for body knowledge early in infancy is a general social cognitive capacity that drives both body and face knowledge, such as a designated cognitive structure or innate predisposition to process social stimuli efficiently (Bhatt et al., 2016; Simion, di Giorgio, Leo, & Bardi, 2011). Such a structure or tendency would account for the previously mentioned rapid acquisition of body knowledge early in life. It is also plausible that expertise in the domain of face processing facilitates knowledge about bodies (Bhatt et al., 2016). This kind of bootstrapping is a likely possibility given that faces and bodies are often seen in conjunction and with parallel social cues. For example, knowledge about sex cues in bodies may be acquired via their correlation with known facial sex cues.

In contrast to the models of body knowledge development discussed above, models of the development of face processing in infancy rarely incorporate body knowledge (e.g., Morton & Johnson, 1991; Pascalis & Kelly, 2009; Simion & Di Giorgio, 2015). This divide in the consideration of facial and body knowledge is surprising given that research indicates that both faces and bodies contribute in an interactive manner to the accurate interpretation of social information such as emotion in adulthood (Martinez, Falvello, Aviezer, & Todorov, 2016). Thus, when considering social cognition on a holistic basis, one must take into account the relationship between faces and bodies. We addressed this issue in the current study by examining whether systematic scanning of bodies by infants is affected by information from the face.

The Current Study

As described earlier, young infants are sensitive to sex information in both faces and bodies (Alexander et al., 2016; Hock et al., 2016; Quinn et al., 2002). In particular, as noted earlier, Alexander et al. found that 3-to 18-month-olds prefer to look at female versus male full-body images. However, that study did not address scanning of specific body parts as a function of sex. In the current study, we examined whether infants prefer to look at the torsos of females over males and the legs of males over females. We chose these body parts to examine because, as described earlier, studies indicate that the torso and leg regions of

images are subject to sex-specific scanning by adults (Hewig et al. 2008; Nummenmaa et al., 2012). Thus, we reasoned that a starting point for the assessment of sex-specific scanning by infants is to examine whether they exhibit systematic attention to female torsos and male legs. We addressed this issue in Experiment 1 by using an eye-tracking system to document infants' look durations to these regions of photographs of males and females. Moreover, the Alexander et al. (2016) study, which found that infants prefer to look at female over male full-body images, did not examine whether facial information affects infants' preferences. In Experiment 2 of the current study, we examined whether systematic scanning of body parts is independent of information gleaned from faces. This allowed us to address the relationship between facial and bodily knowledge early in life. Furthermore, the ages of the infants in the youngest age group studied by Alexander et al. (2016) ranged from 3-7 months. Prior research has demonstrated many developmental differences pertaining to body information processing within this age range. For example, Hock et al. (2015) found that 3.5-month-olds fail to match human faces and bodies on the basis of sex while 5-month-olds do. Moreover, 3.5-month-olds fail to match emotions between bodies and vocalization under conditions in which 6.5-month-olds do match (Zieber et al., 2014a). Thus, 3.5-month-olds' knowledge about bodies may not yet be developed enough to exhibit sex-specific scanning, and only older infants may demonstrate this function. On the other hand, infants exhibit sex-specific face processing by this age (Quinn et al., 2002) and, as previously mentioned, 3.5-month-olds are sensitive to body structure and body part proportions (Zieber et al., 2015); it is therefore possible that infants also scan bodies systematically at this age. Thus, we studied 3.5-month-olds in the current study. We also included 6.5-month-olds in order to examine potential developmental differences.

Experiment 1

Experiment 1 examined whether 3.5-month-olds and 6.5-month-olds scan female and male images differently. We specifically examined attention to two areas of interest: the torso and legs. The torso is likely to be important given that female breasts are one of the most obvious secondary sex characteristics present in clothed adults, and, as previously mentioned, female breasts potentially hold special significance to infants as a reinforcing food-source. Furthermore, the research with adults described earlier indicates that the chest and legs are important in adult scanning patterns (Hewig et al., 2008; Nummenmaa et al., 2012). As the current study, to our knowledge, is the first one to examine the scanning of body parts based on sex in infancy, we chose to limit analyses to AOIs where we had a priori reasons to expect differences. Thus, we concentrated on infants' fixation durations to the torso and leg regions of male and female images, although we also documented other aspects of infants' sex-specific processing such as overall fixation durations to male versus female images. It is important to note that the goal of this study was to examine knowledge about sex in infancy as revealed by differential scanning of parts of male versus female images. As such, all critical comparisons contrasted scanning of corresponding areas of male versus female images rather than scanning of different areas within each sex.

Method

Participants

Sixteen 3.5-month-olds (mean age = 104.13 days, $SD = 9.20$; 8 female) and 16 6.5-month-olds (mean age = 194.38 days, $SD = 7.22$; 9 female) were included in the final sample. Data from additional participants were excluded for looking at the stimuli for less than 20% of the duration of the study (3.5-month-olds: $n = 7$; 6.5-month-olds: $n = 5$), or experimenter error (6.5-month-olds: $n = 1$). Participants were recruited from birth announcements and a local hospital, and were predominantly Caucasian (84.4%); none was Hispanic. Two participants were Asian, one was African American, and two were biracial (Asian/Caucasian, African American/Caucasian).

Stimuli

The stimuli used in this experiment were color photographs of four adult males and four adult females. As the purpose of this investigation was to determine whether infants systematically scan male and female images, not which specific factors are involved in making sex assignments, we did not alter features that vary naturally between male and female faces. Accordingly, on average, the female models had longer hair than males, and the male models ranged from being clean-shaven to having a moderate beard. All actors wore white shirts and blue jeans while standing with their legs spread and arms at their sides (Figure 1A).

Both upright and inverted stimuli were utilized in this experiment. Prior research indicates that infants' processing of body information is impaired by the inversion of body images; for example, 6.5-month-old infants succeed on intermodal matching tasks between bodies and vocalizations based on emotion only when images are presented in their upright orientations (Zieber et al., 2014a, 2014b). We sought to examine whether inversion also impairs the scanning of male and female bodies such that sex specific scanning patterns would be present in upright but not inverted orientations. Each infant was exposed to four images of a single female and a single male (female upright, female inverted, male upright, and male inverted), each repeated twice. Across infants, four pairs of male/female images were used. On average, the stimuli were 224.60 cm^2 and subtended 14.39° and 6.96° of vertical and horizontal angle, respectively. The sizes of critical parts examined in this study are shown in Table 1.

Apparatus and Procedure

During the study, infants were seated on a parent's lap in a darkened chamber, approximately 65 cm in front of a 58 cm computer monitor. Parents wore opaque glasses to prevent them from seeing the test images, and they were instructed to not direct their infant's looking in any way. Infants were tested on eight 12 s trials. A single image (male or female) was presented in the center of the screen on a gray background on each trial. Preceding every trial, an attention-getter consisting of alternating colored shapes appeared on the screen to direct the infant's focus to the center of the screen. Once the infant looked toward the attention-getter, the test stimulus appeared in the center of the screen. The sex and orientation of the first stimulus was counterbalanced across infants. The remaining seven

trials were randomly presented with the constraint that the same sex or the same orientation was never presented consecutively more than twice.

A Tobii TX300 eye-tracker was used to record infants' looks. The eye-tracker's cameras recorded the reflection of an infrared light source on the cornea relative to the pupil from both eyes at a frequency of 300 Hz. The average accuracy of this eye-tracker according to the manufacturer is in the range of .5 to 1 degree, which approximates to a .5-1 cm area on the screen with a viewing distance of 65 cm. The eye-tracker compensates for head movements, which typically result in a temporary accuracy error of approximately 1 degree and a 100 ms recovery time to full tracking ability after movement offset.

Before starting data collection, each infant's eyes were calibrated using a 5-point infant calibration procedure in which a 23.04 cm² red and yellow rattle coupled with a rhythmic sound was presented sequentially at five locations on the screen (i.e., the four corners and the center). An experimenter controlled the calibration process with a key press to advance to the next calibration point after the infant was judged (via a live video feed) to be looking at the current calibration point. The calibration procedure was repeated if calibration was not obtained for both eyes in more than one location. Eye-tracker calibration and stimulus presentation were controlled by Tobii Studio 3.3.1 software (Tobii Technology AB; www.tobii.com). The I-VT fixation filter provided within Tobii Studio was used to classify which eye movements were considered to be valid fixations. A fixation was defined as any look that exceeded 60 ms while remaining within a 0.5° radius. This criterion removes noise from the data, such as sporadic eye movements. Such a criterion is necessary due to the precise nature of the data being collected (i.e., attention to specific body regions) and is similar to the criteria used in prior studies of infants' scanning (Hunnius, de Wit, Vrins, & von Hofsten, 2011; Papageorgiou et al., 2014; Xiao et al., 2014). Additionally, data from the first 500 ms of each trial were discarded. This adjustment removes artificially inflated looking times to the center of the stimulus as it appears directly behind the attention getter. This criterion is similar to those used in previous studies of body scanning (e.g., Kret et al., 2013).

To analyze the scanning data, areas of interest (AOIs) were defined around the torso (on average 17.43 cm², 7.76% of the stimulus area), legs (on average 36.00 cm², 16.03% of the stimulus area), and head (on average 8.42 cm², 3.75% of the stimulus area), as well as around the whole stimulus (the gray rectangle; on average 224.60 cm², 15.47% of the viewing area), see Figure 1B. The AOIs were identical in size and shape within each male and female pair. In other words, the leg AOIs were identical across all images a particular infant saw. The same was true for the torso, head, and whole stimulus AOIs. Within a single image, AOIs differed in size, thus the only meaningful comparisons in this study will be look duration to a single AOI across stimuli (e.g., male torso vs. female torso). To allow for the use of identical AOIs within a stimulus pair seen by an infant, AOIs were drawn to encompass the entire relevant feature (i.e., torso, head, legs, or entire stimulus) in both stimuli within the pair. This method allowed for the direct comparison of looking times to each AOI across stimuli without confounding AOI size with stimulus sex. The resulting AOIs are slightly larger than if they had been drawn for each image individually, but they allowed critical comparisons within the same AOI across images. Data were obtained for

total fixation duration to each of the AOIs for each of the four types of stimuli summed across both presentations (i.e., upright female, upright male, inverted female, and inverted male, each presented twice).

Results and Discussion

To examine the role of participant sex in this experiment, a mixed ANOVA with Stimulus Sex (female, male), Orientation (upright, inverted), and AOI (torso, legs) as within-subjects factors and Age (3.5 months, 6.5 months) and Participant Sex (female, male) as a between-subjects factor was conducted. Given that the Stimulus Sex \times AOI interaction was the critical interaction of interest in this experiment, we were particularly interested in how Participant Sex affected this interaction. Critically, neither the Stimulus Sex \times AOI \times Participant Sex interaction, $F(1,28) = 0.41$, $p = .53$, $\eta_p^2 = .04$, nor the Stimulus Sex \times AOI \times Participant Sex \times Age Group interaction, $F(1,28) = 0.13$, $p = .72$, $\eta_p^2 = .005$, was significant, indicating that the sex of the participants did not affect sex-specific scanning of either age group. Consequently, we dropped participant sex from the following main analyses.

General Stimulus Preferences

Data are presented in Table 2. A mixed analysis of variance (ANOVA) was conducted on average total fixation durations to each stimulus type with Orientation (upright, inverted) and Stimulus Sex (male, female) as within-subjects factor and Age (3.5 months, 6.5 months) as a between-subjects factor. There was a significant main effect of Orientation, whereby infants fixated longer on upright stimuli than on inverted stimuli, $F(1,30) = 15.69$, $p = .03$, $\eta_p^2 = .15$, but this effect was qualified by a significant Orientation \times Age interaction, $F(1,30) = 12.44$, $p < .001$, $\eta_p^2 = .29$. When analyzed separately, 6.5-month-olds looked longer at upright images than at inverted images, $t(15) = 5.07$, $p < .001$, $d = 1.26$. This preference for upright images was not demonstrated by 3.5-month-olds, $t(15) = 0.75$, $p = .46$, $d = 0.19$ (see Table 2). No other main effect or interaction was significant.

The lack of an overall looking preference between female and male images was surprising given that Alexander et al. (2016) reported a female preference. However, there are myriad differences in the stimuli and procedures used in the two studies that could account for the difference. For example, in the Alexander et al. study, infants' preferences were tested with images presented side-by-side in a paired-comparison procedure. In contrast, infants in Experiment 1 were tested on a successive procedure with only one image presented at a time. The contrast between paired-comparison versus successive testing might account for the differences in the outcomes of the two studies, as prior research has shown that preferences vary as a function of the nature of the test (Ramsey et al., 2005). Moreover, the current study used photographs of real individuals whereas the Alexander et al. study used computer-generated images. Furthermore, infants in the current study were only tested on male and female images whereas infants in the Alexander et al. study were also concurrently tested on preferences within male and within female categories. Also, infants in the current experiment were tested on both upright and inverted images, whereas infants in the Alexander et al. study were tested only on upright images. Other factors, such as trial lengths, number of trials, and display sizes also differed between the two studies. One or

more of these factors could account for the different outcomes of the current and Alexander et al. (2016) study.

Because there were individual differences in terms of total fixation duration to the stimuli used, the dependent measure for the specific body part analysis was the proportion of total fixation duration to the individual AOIs rather than the raw look durations. The head, torso, and leg proportions were calculated by dividing each infant's total fixation duration to the AOI (head, torso, or legs) across the two test trials of each orientation and sex by the total fixation duration to the whole stimulus AOI across the two trials.

Prior research indicates that infants generally have a preference for female faces over male faces (e.g., Quinn et al., 2002). However, to our knowledge, no study has examined whether infants show a preference between male and female faces when both the head and body are present. To examine this possibility, we conducted a mixed ANOVA on proportion fixation durations to the head AOI with Orientation (upright, inverted) and Stimulus Sex (male, female) as a within-subjects factor and Age (3.5 months, 6.5 months) as a between-subjects factor. Means are presented in Table 2. Critically, neither the main effect of Stimulus Sex, $F(1,30) = 0.59, p = .59, \eta_p^2 = .01$, nor the Stimulus Sex \times Age interaction was significant, $F(1,30) = 1.04, p = .32, \eta_p^2 = .03$. There was, again, a significant main effect of Orientation, whereby infants fixated longer on upright faces than on inverted faces, $F(1,30) = 48.47, p < .001, \eta_p^2 = .62$. The only other significant interaction was Stimulus Sex \times Orientation, $F(1,30) = 4.95, p = .03, \eta_p^2 = .14$, whereby infants looked significantly longer at inverted female faces than inverted male faces $t(31) = 2.71, p = .01, d = 0.47$, but this effect was not present in upright images, $t(31) = -1.10, p = .28, d = 0.19$. Thus, infants did not look reliably longer at the female face than at the male face in the context of the whole body images shown in this experiment.

Scanning of Torso and Legs

A mixed ANOVA with Stimulus Sex (female, male), Orientation (upright, inverted), and AOI (torso, legs) as within-subjects factors and Age (3.5 months, 6.5 months) as a between-subjects factor was conducted. The main effect of age was not significant, $F(1,30) = 0.024, p = .88, \eta_p^2 = .001$, nor did age interact with any other factors. Critically, age did not significantly qualify the interaction of interest (Stimulus Sex \times AOI); that is, Stimulus Sex \times AOI \times Age was not significant, $F(1,30) = 1.33, p = .26, \eta_p^2 = .04$. Thus, there was no evidence to suggest that the performance of 3.5-month-olds differed from that of 6.5-month-olds.

There was a significant main effect of Orientation, $F(1,30) = 61.24, p < .001, \eta_p^2 = .67$, whereby infants looked proportionally longer at inverted AOIs than upright AOIs. Additionally, there was a significant main effect of AOI, $F(1,30) = 29.79, p < .001, \eta_p^2 = .50$; however, these were qualified by a significant Orientation \times AOI interaction, $F(1,30) = 51.26, p < .001, \eta_p^2 = .63$, in which proportional fixation times were greater for AOIs presented on the top of the screen (i.e., the torso in upright conditions and the legs in inverted conditions) than those presented on the bottom of the screen.

It should be noted that, given that we did not equate for AOI size within images, comparisons across AOIs within a category of images would be misleading. For example, given that the torso AOI is roughly half the size of the leg AOI, one would expect that the proportion looking to the legs would be twice that of the torso if the infants were scanning the images randomly. As our primary concern was in comparisons across males versus females, not contrasts within a sex, we focused on comparisons within individual AOIs on males and females, which avoided any ambiguity due to disparities in position and size across different AOIs within images.

Recall that the primary goal of this experiment was to examine whether infants look longer at the torso of females and the legs of males. The interaction addressing this question (Stimulus Sex \times AOI) was significant, $F(1,30) = 29.08$, $p < .001$, $\eta_p^2 = .49$ (see Figure 2), but the three-way interaction of Stimulus Sex \times AOI \times Orientation was not significant, $F(1,30) = 3.82$, $p = .06$, $\eta_p^2 = .11$. Thus, further analyses were collapsed across orientation.

Overall, the significant Stimulus Sex \times AOI interaction (see Figure 2) indicated that infants' distribution of looks to the torso and legs was affected by the sex of the stimulus. To further analyze this interaction, we used pre-planned t -tests to directly compare infants' proportional look durations to the torsos and legs. Infants looked more at the female torso ($M = 0.27$; $SE = 0.03$) than at the male torso ($M = 0.16$; $SE = .02$), $t(31) = 4.40$, $p < .001$, $d = 0.78$. In contrast, they looked proportionally less at the female legs ($M = 0.30$; $SE = 0.02$) than at the male legs ($M = .42$; $SE = 0.02$), $t(31) = -4.79$, $p < .001$, $d = 0.85$. Thus, together, 3.5- and 6.5-month-olds systematically looked longer at the torso of females and the legs of males (Figure 2).

Although there was no evidence from the ANOVA to indicate that there was a difference in performance as a function of age, we conducted pre-planned t -tests to examine whether the overall pattern of differential looking to the torso and legs of males and females was seen at both 3.5 and 6.5 months (see Figure 2). At 3.5 months, infants looked more at the torso of females than the torso of males, $t(15) = 3.92$, $p = .001$, $d = 0.98$, but less at the legs of females than of males, $t(15) = -3.88$, $p = .001$, $d = 0.97$. Similarly, 6.5-month-olds looked more at the torso of females than of males, $t(15) = 2.41$, $p = .03$, $d = 0.60$, and less at the legs of females than of males, $t(15) = -2.92$, $p = .01$, $d = 0.73$. Thus, in the case of both 3.5-month-olds and 6.5-month-olds, there was clear evidence that infants look longer at the torso of females and legs of males. These results suggest that sex-specific scanning of bodies originates quite early in life.

Experiment 2

In this experiment, we examined the relationship between face and body information processing in infancy while also addressing whether infants' performance in Experiment 1 was due to low-level features that may be unrelated to sex. To address the first issue, we examined whether systematic scanning of bodies is dependent upon sex information derived from the face/head region of images. Prior research indicates that at least some aspects of infants' processing of social information in bodies are independent of facial information. For example, Zieber et al. (2014a, 2014b) found that 6.5-month-olds perceive emotions in body

posture and movement even in the absence of emotional information in faces. It is thus possible that infants' sex-specific scanning seen in Experiment 1 is independent of facial/head information. On the other hand, there are reports in the literature suggesting that body knowledge is much slower to develop in infancy compared to facial knowledge (Slaughter, Heron-Delaney, & Christie, 2012; for a different perspective, see Bhatt et al., 2016). It is therefore possible that infants' scanning of bodies is primarily an offshoot of facial processing, such that facial information is necessary for infants to exhibit systematic scanning of bodies.

We examined this issue in Experiment 2 by testing infants with stimuli in which the heads of the images were removed. That is, infants were tested on only the portion of the body below the neck. If infants' scanning is affected by the lack of head/facial information, then it would indicate that this kind of information is necessary for infants to engage in sex-specific scanning of body parts. If, however, infants continue to systematically scan in the same way as in Experiment 1 even in the absence of the head, then infants do not need facial/head information for sex-specific scanning.

Given the lack of an inversion effect in Experiment 1, and the fact that male and female stimuli were allowed to vary naturally, the testing of infants with headless stimuli also served as a control condition to examine whether factors other than sex information could have led to infants' systematic scanning in Experiment 1. Note that size differences of body parts cannot explain the results. As indicated in Table 1, on average, the torso of males were larger than the torso of females but no other differences were statistically significant. Yet, infants in Experiment 1 attended more to the torso of females than males and also exhibited differences in attention to the legs of males and females even though they did not reliably differ in size. Nevertheless, recall that the stimuli in Experiment 1 were not perfectly matched across males and females (for example, clothing was similar, but not identical), thus, it is possible that some feature other than the sex of the image drove infants' sex-specific scanning of torsos and legs. However, these same idiosyncrasies were present in the headless condition of Experiment 2. Thus, if removing the head neutralized the effect of stimulus sex, then it would have indicated that the scanning patterns observed in Experiment 1 were not driven by arbitrary stimulus features (such as clothing). If, on the other hand, infants continue to exhibit systematic scanning even in the absence of the head/face information, then one cannot rule out the possibility that some idiosyncratic features of the stimuli rather than sex may have driven performance in Experiment 1.

Method

Participants

Sixteen 3.5-month-olds (mean age = 105.00 days, $SD = 8.23$; 11 female) and 16 6.5-month-olds (mean age = 195.75 days, $SD = 11.16$; 7 female) were included in the final sample. Data from additional participants were excluded for looking at the stimuli for less than 20% of the duration of the study (3.5-month-olds: $n = 3$; 6.5-month-olds: $n = 9$) or experimenter error (6.5-month-olds: $n = 1$). Participants were recruited in the same manner as in Experiment 1 and were predominantly Caucasian (90.6%); two participants were Hispanic.

One participant was African American, and two were biracial (African American/Caucasian or Asian/Caucasian).

Stimuli, Apparatus, and Procedure

Headless stimuli were created from the stimuli used in Experiment 1 (see Figure 3). Adobe Photoshop was used to remove the head from the whole person stimuli. The stimuli were not altered in any other way. Infants were tested using the same procedure and equipment as in Experiment 1. Moreover, the AOIs and the dependent measures used in this experiment were identical to those used in Experiment 1. That is, the torso, legs, and overall AOIs (see Figure 1) were exactly the same in this experiment as in Experiment 1, and the look duration proportions were derived exactly as in Experiment 1.

Results and Discussion

To examine the potential role of participant sex in this experiment, a preliminary mixed ANOVA with Stimulus Sex and AOI as within-subjects factors and Participant Sex (female, male) and Age (3.5 months, 6.5 months) as between-subjects factors was conducted. Neither the Stimulus Sex \times AOI \times Participant Sex interaction, $F(1,28) < .001$, $p = .98$, $\eta_p^2 < .001$, nor the Stimulus Sex \times AOI \times Participant Sex \times Age interaction, $F(1,28) = 0.003$, $p = .96$, $\eta_p^2 < .001$, was significant, indicating that the sex of the participants did not affect sex-specific scanning of either age group. Consequently, we dropped participant sex from the following analyses.

General Stimulus Preferences

A mixed ANOVA was conducted on average total fixation durations to each stimulus type with Orientation (upright, inverted) and Stimulus Sex (male, female) as within-subjects factors and Age (3.5 months, 6.5 months) as a between-subjects factor. Means are presented in Table 3. None of the main effects or interactions was significant.

It is possible that infants' overall look durations in this experiment could have differed from Experiment 1 due to the greater novelty of the face component of the stimuli. To examine this issue, fixation durations were collapsed across stimulus type and an ANOVA was conducted with Age (3.5 months, 6.5 months) and Experiment (1, 2) as between-subjects factors. There was a significant main effect of age group whereby 6.5-month-olds displayed longer fixation durations than 3.5-month-olds, $F(1,60) = 6.26$, $p = .02$, $\eta_p^2 = .09$. Neither the main effect of Experiment, $F(1,60) = 0.10$, $p = .75$, $\eta_p^2 = .002$, nor the Age \times Experiment interaction, $F(1,60) = 0.36$, $p = .55$, $\eta_p^2 = .006$, was significant, indicating that overall attention did not significantly differ between the experiments. Furthermore, given that the primary analyses in this study used proportional measures of looking, any differences in overall looking should not systematically impact the results.

Scanning of Torso and Legs

As in Experiment 1, the dependent measure was proportion fixation duration to the torso and leg AOIs over the whole stimulus AOI. In order to examine the effects of the presence/absence of the head on infants' attention, we analyzed the combined data from Experiment 1

(with head) and Experiment 2 (without head) using an Experiment \times Stimulus Sex \times AOI \times Age ANOVA. This analysis revealed a significant Experiment \times Stimulus Sex \times AOI interaction, $F(1,60) = 13.04$, $p = .001$, $\eta_p^2 = .18$ but no Stimulus Sex \times AOI \times Experiment \times Age interaction, $F(1,30) = 2.64$, $p = .11$, $\eta_p^2 = .04$. This finding indicates that both 3.5- and 6.5-month-olds' sex-specific scanning of bodies significantly differed between the whole body (Experiment 1) and headless conditions (Experiment 2).

In order to examine infants' scanning in the absence of head information, we separately analyzed the data from Experiment 2. A mixed ANOVA with Stimulus Sex (female, male), Orientation (upright, inverted), and AOI (torso, legs) as within-subjects factors and Age (3.5 months, 6.5 months) as a between-subjects factor was conducted. The only significant main effects were those of Orientation, $F(1,30) = 9.02$, $p = .01$, $\eta_p^2 = .23$, and AOI, $F(1,30) = 63.69$, $p < .001$, $\eta_p^2 = .68$. However, these effects were qualified by an Orientation \times AOI interaction, $F(1,30) = 90.12$, $p < .001$, $\eta_p^2 = .75$. Thus, infants looked longer at inverted than upright AOIs, at legs more than torsos, and at AOIs presented at the top of the screen (i.e., the torso in upright conditions and the legs in inverted conditions) compared to those presented on the bottom of the screen. Age was not a significant main effect, $F(1,30) = 1.92$, $p = .18$, $\eta_p^2 = .06$, and only interacted significantly with AOI; i.e., Age \times AOI was significant, $F(1,30) = 12.79$, $p = .001$, $\eta_p^2 = .30$, indicating that the magnitude of difference between looking to torsos compared to legs was greater for 6.5-month-olds than 3.5-month-olds.

In contrast to Experiment 1, the critical interaction that examined differential looking to the torso and leg AOIs, Stimulus Sex \times AOI, was not significant in Experiment 2, $F(1,30) = 0.08$, $p = .78$, $\eta_p^2 = .003$. Moreover, Orientation did not qualify this interaction; i.e., Orientation \times Stimulus Sex \times AOI was not significant, $F(1,30) = 0.004$, $p = .95$, $\eta_p^2 < .001$. Furthermore, Age \times Stimulus Sex \times AOI interaction was not significant, $F(1,30) = 1.34$, $p = .26$, $\eta_p^2 = .04$. Consistent with this analysis, planned t -tests like those conducted in Experiment 1 failed to detect significant differences in looking to the torso of females compared to males, $t(31) = 0.03$, $p = .979$, $d = 0.01$, or the legs of males compared to females, $t(31) = 0.48$, $p = .64$, $d = 0.08$. Thus, infants did not exhibit differential looking to the torsos of females and legs of males when the images were presented without the head.

Overall, therefore, there was no evidence to suggest that infants' look durations to the torso and legs varied as a function of sex in Experiment 2 (Table 4). This is in contrast with the results of Experiment 1 in which infants exhibited systematic scanning when they were tested with head/face information. These results demonstrate that sex-specific scanning relies upon the presence of facial/head information. Moreover, sex-specific scanning in Experiment 1 was not simply due to idiosyncratic features of stimuli that were unrelated to sex. Instead, it appears that infants' performance was driven by the sex of the stimuli.

General Discussion

In this study, 3.5- and 6.5-month-old infants scanned male and female bodies differently. Specifically, they looked proportionally longer at the torso of females compared to males and the legs of males compared to females. Furthermore, this effect was not driven by

arbitrary low-level stimulus features in the bodies, as evidenced by the null finding when infants were tested on headless images. The pattern of responding documented in this study suggests early sensitivity to sex categories and specific processing of information from the two categories early in life. Such fine-grained attentional strategies may be a critical precursor to explicit knowledge about sex later in life.

Prior research suggests an association between scanning and level of information processing. For example, infants who exhibit more mature scanning and visual search behavior are superior at object perception (e.g., Amso & Johnson, 2006; Johnson, Davidow, Hall-Harrow, & Frank, 2008; Johnson, Slemmer, & Amso, 2004). Based on such results, Johnson (2010) suggests that visual exploration is vital for the development of object perception. Visual exploration might also be vital for the development of social cognition. For example, Amso, Fitzgerald, Davidow, Gilhooly, and Tottenham (2010) found that infants who scan the eye region are superior at detecting fear in faces than those who gaze at other regions of the face. The fact that infants as young as 3.5 months of age systematically scanned bodies based on their sex in the current study thus suggests that scanning (and presumably the attentional mechanism associated with scanning) facilitates the development of social knowledge about bodies.

The current study also complements previously mentioned studies demonstrating knowledge of bodies very early in life. As noted earlier, Alexander et al. (2016) reported that 3-to 18-month-olds prefer to look at female than to male full-body images. The current study adds to this finding by demonstrating that infants' scanning of parts of bodies (specifically, the torso and legs) is sex-specific. Moreover, the current study indicates that infants as young as 3.5 months of age exhibit sex-specific scanning. Another contribution of the current study is the finding that sex-based systematic scanning of body parts is dependent upon head/face information.

Recall that 3.5-month-olds display sensitivity to body structure pertaining to part locations and proportions (Zieber et al., 2015). Thus, it is plausible that their knowledge of body parts works in conjunction with knowledge of sex, resulting in the differential attention to the torso and legs documented in Experiment 1. However, the combined results of Experiment 1 and Experiment 2 suggest that information from both the face/head and the body is critical for young infants to demonstrate sex-specific scanning patterns. This could be due to underdeveloped knowledge about sex, whereby infants need redundant information from both the face/head and body to exhibit specialized attention to discrete body parts. Alternatively, young infants' sex-specific scanning might be primarily driven by information from the face/head, thus infants may have failed to exhibit specialized scanning in Experiment 2 because facial/head sex information was unavailable. It is important to note, however, that the current research does not directly speak to the issue of whether specific sex information from faces/heads is necessary for systematic body scanning or just any kind of facial/head information would suffice. This is because the absence of any facial/head information in the headless condition may have rendered the stimuli non-human to infants, and may have prevented systematic scanning. In contrast, the presence of a face and head, even if they did not convey sex information, may allow infants to engage in typical scanning based on the information available in the bodies about the sex of individuals. On the other

hand, it is possible that young infants' sex-specific scanning is solely driven by facial information, such that they would exhibit systematic scanning even if the bodies themselves did not differ.

Yet another possibility is that the congruence between face/head and body is the critical factor, not the face/head itself. In other words, younger infants may need information pertaining to sex from both channels (face/head and body; as in Experiment 1) to display appropriate scanning. Thus, the exact nature of the relationship between face and body knowledge is not clear from the current study. However, the current research supports the idea that face and body processing are related to one another early in infancy. Thus, the results constrain future models of social cognition by suggesting that models of face knowledge development and body knowledge development in infancy cannot be considered in isolation but need to be integrated to generate a more holistic and functional picture of development.

It is possible that infants' attention was drawn to the torso area of females in whole images because they have been conditioned to attend to this area. When a child is breastfeeding, the torso area of his/her mother becomes linked with the rewarding experience of eating. Therefore, infants could be exhibiting a conditioned response in the form of increased attention that generalizes to novel females. It is important to note, however, that infants in Experiment 2 did not show increased attention to female torsos (in the absence of facial/head information), so it appears that some level of sensitivity to the femaleness of an image seems to be a critical precursor to this differential attention. Future research comparing infants who are breast-fed to bottle-fed will be an important step in examining this hypothesis. It is important to note that the explanation described above assumes that infants' performance is due to a female/not-female dichotomy, rather than a female/male contrast with separate knowledge of each category. While this would be consistent with previous research demonstrating infants' expertise is greater on female than male stimuli (Quinn et al., 2002), and research suggesting that expert processing of female faces facilitates the processing of male faces such that infants demonstrate an increased ability to categorize images of males when they are low in masculinity (Rennels, Kayl, Langlois, Davis, & Orlewicz, 2016), it does not detract from the finding that infants are modulating attention based on sex category, regardless of how those categories may be represented.

An unexpected finding of this study is that, while infants in Experiments 1 looked less overall at inverted images of bodies compared to upright bodies, this effect did not interact with scanning patterns. In contrast, 3.5-month-olds in Zieber et al. (2015) exhibited systematic inversion effects when tested on preference between intact and part reorganized body images and on discrimination between intact and proportionally distorted bodies. There are many differences between the Zieber et al. studies and the current study that may have led to these different outcomes. Probably the most significant difference is that the current study involved a within-subject design in which each infant was tested on both upright and inverted images in an intermixed manner. This may have resulted in upright images priming sex-related information in the inverted images. In contrast, separate groups of infants were tested on upright and inverted images in Zieber et al. and there would have been no possibility of priming. Another possibility is that differences in the nature of the

information processing examined in the two studies—sex information in the current study versus body structure information in Zieber et al.—led to the different outcomes. That is, given the dramatic differences in the secondary characteristics of males and females, it is possible that sex information is available to infants in full-body images even when they are inverted. The test procedures and the dependent measures used in the current study and the Zieber et al. study also differed in many ways that may have affected the outcomes. For example, infants in the current study saw only one stimulus at a time and the main dependent measures were proportional look durations to the torsos and legs of males and females, whereas infants in the Zieber et al. study were tested using a paired-comparison procedure and the dependent measure was proportion look duration to the distorted image. Thus a variety of factors could have led to the differences in the outcomes of the current and Zieber et al. studies. However, Experiment 2 answered the questions that we sought to answer using stimulus inversion in Experiment 1, namely whether infants' systematic preferences in Experiment 1 were due to low-level image features like the color of clothing. The null results obtained in that experiment indicated that infants' performance in Experiment 1 was not driven by such features.

Furthermore, contrary to previous research that has documented a general preference in infancy for female over male faces (e.g., Quinn et al., 2002; Ramsey-Rennels & Langlois, 2006), infants in Experiment 1 did not look longer at female faces compared to male faces. This discrepancy could be due to the sequential presentation of the images (as against side-by-side comparisons used by Quinn et al., 2002), the small relative size of the faces, or competing biases to look to specific areas of the body. Moreover, unlike in Alexander et al. (2016), infants in the current study failed to exhibit an overall preference between male and female bodies. As noted earlier, this difference could be due to a variety of stimulus and procedural factors. However, despite not exhibiting a preference between male and female faces or full-body images, infants clearly exhibited sex-specific scanning of bodies. This finding indicates that sex identification and preferential looking are not necessarily directly linked.

The fact that infants did not engage in sex-specific scanning when sex cues were present only in the body (i.e., when tested with headless bodies) is also noteworthy in indicating how sensitivity to the sex of a stimulus is related to scanning. It appears from the combined results of Experiments 1 and 2 that infants look longer at female torsos and at male legs because they are cognizant of the maleness or femaleness of the stimulus, not because female torsos are inherently more salient than male torsos or because male legs draw more attention than female legs. In other words, if young infants' attention was drawn to the female torso due to some low level stimulus feature, they should have shown similar performance in the whole image and headless conditions. Such similarity was not found. This discrepancy suggests that initial discernment of stimulus sex subsequently drove systematic scanning. However, it is also possible that, during the stream of processing, different levels of attention to sex information in the stimuli and scanning build upon each other in an interactive manner. In other words, an initial impression of sex may be followed by systematic scanning, which leads to a greater degree of certainty; in turn, this certainty leads to more specific scanning, and so on. This spiral might finally lead to veridical knowledge about the sex of individuals and accurate derivation of sex-relevant information.

A general social cognition mechanism, as described by Bhatt et al. (2016), could underlie the differential scanning patterns documented in this study. As infants are exposed to bodies differing in socially significant ways, such as sex, they may realize that specific areas of the bodies are most diagnostic. This realization could lead to a positive feedback loop, whereby infants attend to areas that house the most relevant information and thus gain richer knowledge of this area. This increased knowledge of the region could then increase attention to the same region in novel exemplars. That is, specific attention to body parts could be rapidly learned and lay the foundation for later social interactions. Such a mechanism would likely function in other domains; therefore, future research should seek to examine if scanning patterns vary as a function of other social categories, such as emotion.

In conclusion, the current study found that infants scan female and male bodies differently. The systematic scanning seen here suggests that infants begin to attend to socially informative cues about people quite early in life. These findings also contribute to a growing literature showing the complexity of human body knowledge in infancy (Bhatt et al., 2016) and demonstrate the value of scanning patterns as a sensitive metric of developing body knowledge. Additional research should seek to document the precise nature and function of these scanning patterns and how they interact with other stimulus characteristics, such as participant and stimulus race, age, and emotion. Furthermore, examining infants' scanning patterns of dynamic bodies and bodies in natural contexts will be a critical step in understanding how category specific scanning patterns, such as those documented in the current study, may be utilized in real life situations.

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Highlights

- Systematic scanning of images indicates efficient processing of relevant information
- Adults exhibit sex-specific scanning of the breast and leg regions of human images
- We found that 3.5- and 6.5-month-olds preferentially scan the torsos of females and legs of males
- Young infants systematically process cues that are significant sex-related cues in adulthood

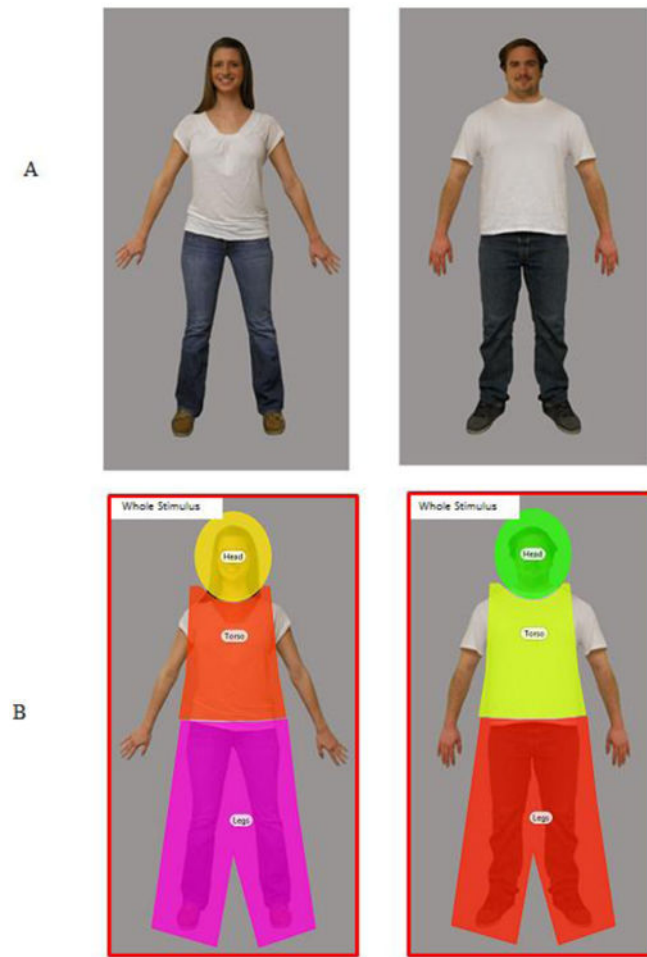


Figure 1. (A) Examples of stimuli used in Experiment 1. (B) The shapes superimposed on the body images are examples of AOIs used in data analysis. These shapes were not visible to infants during the experiments.

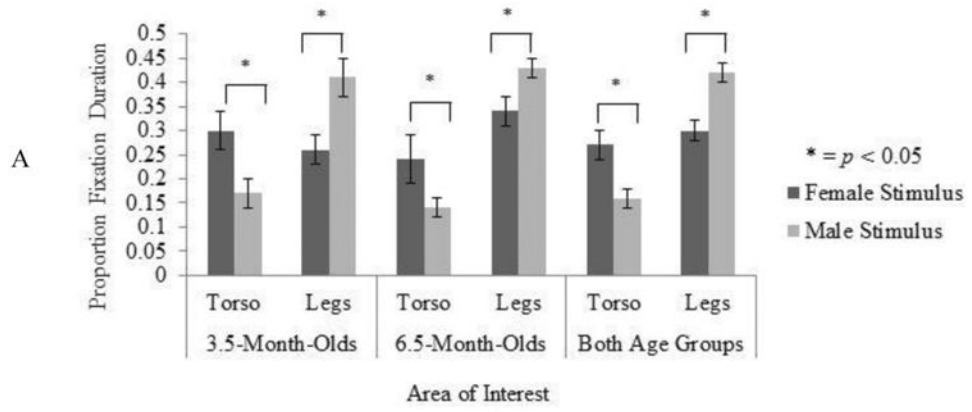


Figure 2.
Proportion fixation durations exhibited by infants in Experiment 1.



Figure 3.
Examples of the headless female and male stimuli used in Experiment 2.

Table 1
Average sizes of specific body parts of the stimuli used in Experiment 1 and Experiment 2
(note that the face was not present in Experiment 2)

	<u>Male Stimuli</u>		<u>Female Stimuli</u>	
	<u>Height × Width (cm)[#]</u>	<u>Area (cm²)</u>	<u>Height × Width (cm)[#]</u>	<u>Area (cm²)</u>
	<i>M (SE) × M (SE)</i>	<i>M (SE)</i>	<i>M (SE) × M (SE)</i>	<i>M (SE)</i>
Face	2.08 (0.17) × 1.53 (0.11)	95.65 (16.34)	2.02 (0.09) × 1.48 (0.24)	88.65 (13.67)
Torso	5.90 (0.31) × 3.78 (0.38)	744.48 (80.10)*	5.52 (0.31) × 3.57 (0.25)	616.17 (44.03)*
Legs	8.24 (0.15) × 4.32 (0.63)	849.76 (54.61)	8.60 (0.27) × 4.20 (0.31)	814.45 (53.60)

[#]Maximum height and width spanned by the body part

*Independent Samples t-test comparing males to females, $p < 0.05$

Table 2
Average total fixation duration (sec) to each stimulus type and average proportion fixation duration to faces in Experiment 1

Stimulus Type	3.5-month-olds <i>M (SE)</i>	6.5-month-olds <i>M (SE)</i>	Both Age Groups <i>M (SE)</i>
<i>Fixation Duration</i>			
Upright Female	4.78 (0.81)	8.08 (0.94)	6.43 (0.68)
Upright Male	4.13 (0.79)	7.66 (0.69)	5.89 (0.61)
Inverted Female	4.96 (1.02)	6.63 (0.82)	5.79 (0.66)
Inverted Male	4.70 (0.92)	5.56 (0.73)	5.13 (0.58)
<i>Fixation Proportion</i>			
Upright Female Face	.31 (.07)	.46 (.07)	.38 (.05)
Upright Male Face	.33 (.07)	.55 (.06)	.43 (.05)
Inverted Female Face	.14 (.06)	.12 (.04)	.13 (.04)
Inverted Male Face	.03 (.02)	.06 (.03)	.05 (.02)

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Table 3
Average total fixation duration (sec) to each stimulus type in Experiment 2

Stimulus Type	3.5-month-olds	6.5-month-olds	Both Age Groups
	<i>M (SE)</i>	<i>M (SE)</i>	<i>M (SE)</i>
Upright Female	6.05 (0.94)	6.58 (0.45)	6.32 (0.57)
Upright Male	5.40 (0.99)	5.92 (0.92)	5.66 (0.67)
Inverted Female	5.04 (1.01)	6.79 (0.87)	5.92 (0.68)
Inverted Male	4.82 (.81)	7.78 (0.96)	6.30 (0.67)

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Table 4
Average proportion fixation duration to each AOI over fixation duration to the entire stimulus in Experiment 2

AOI	3.5-month-olds		6.5-month-olds	
	<i>M (SE)</i>	<i>t-score</i> [#]	<i>M (SE)</i>	<i>t-score</i> [#]
Female Torso	.27 (.05)	1.18	.25 (.02)	1.77
Male Torso	.32 (.03)		.19 (.03)	
Female Legs	.43 (.04)	0.37	.56 (.02)	0.30
Male Legs	.42 (.03)		.55 (.04)	

[#]
all p s > .05

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