Differential gaze behavior towards sexually preferred and non-preferred human figures

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Abstract

The gaze pattern associated with image exploration is a sensitive index of our attention, motivation and preference. To examine whether an individual's gaze behavior can reflect his/her sexual interest, we compared gaze patterns of young heterosexual men and women (M = 19.94 years, SD = 1.05) while viewing photos of plain-clothed male and female figures aged from birth to sixty years old. Our analysis revealed a clear gender difference in viewing sexually preferred figure images. Men displayed a distinctive gaze pattern only when viewing twenty-year-old female images, with more fixations and longer viewing time dedicated to the upper body and waist-hip region. Women also directed more attention at the upper body on female images in comparison to male images, but this difference was not age-specific. Analysis of local image salience revealed that observers' eye-scanning strategies could not be accounted for by low-level processes, such as analyzing local image contrast and structure, but were associated with attractiveness judgments. The results suggest that the difference in cognitive processing of sexually preferred and non-preferred figures can be manifested in gaze patterns associated with figure viewing. Thus, eye-tracking holds promise as a potential sensitive measure for sexual preference, particularly in men.

Introduction

Visual exploration of our environment involves a series of saccades to direct our fixation to regions that are informative or interesting to us. The preferred regions within a scene are often inspected earlier and attract more fixations and longer viewing time (Henderson, 2003). This preference-biased gaze distribution is shown to have a causal effect on conscious preference decision making (Shimojo, Simion, Shimojo, & Scheier, 2003). Gaze patterns hence provide a real-time behavior index of ongoing perceptual and cognitive processing, and could be sensitive indices of our attention, motivation, and preference, especially when exploring scenes of high ecological validity (Henderson, 2003; Isaacowitz, 2006; Rayner, 1998).

Compared with those well studied cognitive processes, such as saccadic eye movements in reading, scene perception and face perception, the gaze pattern in the process of body perception and sexual preference is less well documented. Sexual preference refers to a dispositional sexual attraction, usually towards mature humans, but occasionally directed to children, animals and non-living objects (Chivers & Bailey, 2005). Assessing an individual's sexual preference is important for experimental research and clinical applications, for example, evaluating the effectiveness of treatment and predicting the likelihood of offence/re-offence for individuals with a sexual offending history (Hanson & Morton-Bourgon, 2005). The conventional measurements, such as phallometric assessment and self report, often attract criticism that they are intrusive (e.g., phallometric assessment), susceptible to deception (e.g., self-report), and that they lead to high levels of false negative and false positive identifications (Flak, Beech, & Fisher, 2007; Kalmus & Beech, 2005). Given the aforementioned unique characteristics of gaze patterns, including its advantages over currently established methodologies (naturalistic and automatic, difficult to be inhibited or altered consciously) (Nummenmaa, Hyona, & Calvo, 2006), it can help us to understand cognitive processing of visually salient sexual information and may be a useful measure of sexual interest/preference. After all, we need to attend to something before we can assess it for its attractiveness.

Several recent eye-tracking studies have suggested the use of gaze pattern analysis (allocation of fixation and viewing time within images) in sexuality research. Lykins, Meana and Kambe (2006) first revealed a different viewing pattern towards erotic and non-erotic images, with participants dedicating more fixations and longer viewing time to the bodies within erotic photos in comparison to non-erotic photos. They and other researchers later demonstrated a gender difference in visual processing of same and opposite sex bodies. The heterosexual men looked significantly longer at opposite sex figures in both erotic and non-erotic images, while heterosexual women distributed their visual attention evenly between opposite and same sex figures (Lykins, Meana, & Strauss 2008). Additionally, Rupp & Wallen (2007) demonstrated that women spent longer viewing same-sex figures than men when presented with erotic photographs. These findings demonstrate that cognitive differences in the way men and women appraise sexual stimuli can be evidenced at the visual level. Body region analysis further revealed that both men and women tend to gaze at the chest and abdomen area when judging females' attractiveness and body fat (Cornelissen, Hancock, Kiviniemi, George, & Tovee, 2009; Hewig, Trippe, Hecht, Straube, & Miltner, 2008). Male observers also directed more attention towards the waist-hip region in females with lower waist-to-hip ratio, suggesting the importance of this region in body viewing (Suschinsky, Elias, &

Krupp, 2007). However, it remains unclear which specific body parts are crucial for inducing different gaze patterns in men and women, how viewers' gaze patterns vary as a function of gender and age of the viewed human figure, and to what degree the differential gaze distribution to the same and opposite sex figures could be accounted for by low-level local image properties and the role of attraction.

In this exploratory study we examined whether we could explicitly differentiate an individual's natural gaze pattern in viewing plain-clothed, full figure images of different gender and age groups (infant, child, young-, middle- and older-adults), and to what degree this spontaneous gaze behavior is related to high-level mental process such as attractiveness judgments. As our gaze behavior is closely linked with perceptual and cognitive processing, it is likely that viewing of sexually preferred figures would elicit a different distribution of fixations and viewing time within the figure images. We hypothesized that men and women would show a differential gaze strategy when viewing preferred and non-preferred figures, with this strategy also associated with body regions important for assessing sexual interest, and being related to the age of the viewed figure. Furthermore, we predicted that this differential gaze distribution would not be solely determined by low-level image salience (such as local image contrast and structure), but would be associated with high-level cognitive processing such as judging attractiveness.

Method

Participants

Fifteen male and fifteen female undergraduate students, aged between 18 to 23 years old (M = 19.94 years, SD = 1.05), participated in this study in return for course credit. All participants were white and British ethnic origin with uncorrected normal visual acuity. All Participants reported heterosexual orientation and a preference for age-matched sexual partners (assessed by self-report). To control for possible hormonal influences on visual attention (Rupp & Wallen, 2007), all women were using oral contraceptives. Informed consent was obtained from each participant, and ethical approval was obtained from a departmental ethics committee.

Procedure

Digitized grey scale images were presented through a ViSaGe graphics system (Cambridge Research Systems) and displayed on a gamma-corrected color monitor (30.0 cd/m^2 background luminance, 100 Hz frame rate, Mitsubishi Diamond Pro 2070SB) with the resolution of 1024 × 768 pixels. At a viewing distance of 57 cm the monitor subtended a visual angle of 40 × 30°.

Presented images, sampled from fashion catalogues, were 50 full-body figures of white ethnic origin and included five age groups: babies, pre-pubescent children around 10 years old, adults in their early twenties, adults in their late thirties or early forties, and adults in their sixties (10 images per age group with equal proportion of each gender). All figures were plain-clothed in summer or sports wear and portrayed with either neutral or happy facial expressions. We did not choose naked figures as clothed pictures are more common in our daily environment, and most individuals' first feelings of romantic attraction towards someone occur when the person is clothed (Lykins et al., 2008). All the images were gamma-corrected and displayed once in a pseudo-random order at the centre of the screen with a resolution of 600 × 300 pixels (22 × 11°).

During the experiments the participants sat in a chair with their head restrained by a chin rest, and viewed the display binocularly. To calibrate eye movement signals, a small red fixation point (FP, 0.2° diameter, 15 cd/m^2 luminance) was displayed randomly at one of 25 positions (5 × 5 matrix) across the monitor. The distance between adjacent FP positions was 6°. The participant was instructed to follow the FP and maintain fixation for 1 s. After the calibration procedure, the trial was started with a FP displayed on the centre of monitor. If the participant maintained fixation for 1 s, the FP disappeared and a image was then presented for 5 s. The participant passively viewed the images with the task instruction of "viewing the pictures as you normally do". It was considered that in the absence of instrumental responding, our participants' viewing behavior should be as natural as possible. The inter-trial interval was set to 1.5 s.

Horizontal and vertical eye positions were measured using a Video Eyetracker Toolbox with 50Hz sampling frequency and up to 0.25° accuracy (Cambridge Research Systems). The software developed in Matlab computed horizontal and vertical eye displacement signals as a function of time to determine eye velocity and position. Fixation locations were then extracted from the raw eye tracking data using velocity (less than 0.2° eye displacement at a velocity of less than 20°/s) and duration (greater than 50 ms) criteria (Guo, Mahmoodi, Robertson, & Young, 2006).

Data Analysis

While determining fixation and viewing time allocation within images, we divided each figure into four different feature regions: face (including hair and neck), upper body (from the base of the neck to the end of the rib cage), waist-hip region (including the stomach, hips and pubic region) and limbs. Each fixation was then characterized by its location among feature regions and its time of onset relative to the start of the trial. To calculate the proportion of fixation and viewing time allocated at each feature region, two commonly used measurements in eye tracking studies to indicate the amount of interest and processed information by the viewers (Henderson, 2003), the number of fixations and associated viewing time (sum of individual fixation durations) directed at each feature region, was normalized to the total number of fixations and total viewing time sampled in that trial.

As the same feature region across different figures may vary in size (i.e., babies usually have larger 'face' area than adults), the proportion of the areas of a particular figure feature relative to the whole image was subtracted from the proportion of fixations and viewing time directed at that figure feature in a given trial. Any difference in fixation distribution and viewing time from zero means that this particular figure feature attracted more or less fixations than predicted by a uniform viewing strategy (Dahl, Wallraven, Bulthoff, & Logothetis, 2009; Guo, Tunnicliffe, & Roebuck, 2010). Thus, negative values demonstrate less viewing than predicted by region size, and positive values demonstrate more viewing than predicted by region size.

During the analysis, for each participant we averaged fixation and viewing time distribution sampled from figures with participants' preferred gender and non-preferred gender, and/or preferred age and non-preferred age. All our 20-year-old participants reported heterosexual orientation and 20-year-old as their preferred age of sexual partner. Preferred gender referred to the opposite sex image to the participant, and preferred age referred to results from 20-year-old images. Unless specified in the results section, a series of repeated-measures Analysis of Variance (ANOVA) were used to compare fixation and viewing time allocation across different types of figure images. Typically, participant gender was the between-subjects variable, with gender preference, age, and body region as within-subjects variables. For each ANOVA, Greenhouse-Geisser corrections were applied where sphericity was violated. Follow-up tests were conducted in the form of planned comparisons to investigate interaction effects, and post-hoc test with Bonferroni correction for main effects where necessary. For the analysis applied in the study of image attractiveness, we utilised a Friedman test.

Results

Differential gaze pattern to preferred and non-preferred images

We first examined whether figures of different gender and age group presented in the free-viewing task attracted a similar amount of fixations from men and women. As shown in Table 1, on average our viewers allocated 8.7 – 10.6 fixations to explore different images, of which at least 97% of fixations were located on the figures. A 2 (participant gender) × 2 (gender preference) × 5 (age group of figure) ANOVA with averaged number of fixations attracted by each type of figure as the dependent variable revealed a significant effect of age group ($F(4, 112) = 10.44$, $p < .001$, $\eta_p^2 = .27$) and preference ($F(1, 28) = 5.05$, $p < .05$, $\eta_p^2 = .15$). Specifically, regardless of participants' gender, the viewers tended to make more fixations while viewing figures of their preferred gender and preferred age (20-year-old). The least number of fixations were shown when participants explored the youngest and oldest aged bodies (babies and 60-year-olds).

[TABLE 1 HERE]

We then examined whether men and women demonstrated the same gaze pattern in viewing figures of their preferred age (20-years-old) and gender in comparison with those of their preferred age but non-preferred gender. Two 2 (participant gender) × 2 (gender preference) × 4 (figure regions) ANOVAS, with proportion of fixations and viewing time allocated at each figure region as dependent variables revealed a significant main effect of figure regions (fixation $F(2, 58) = 141.21$, $p < .001$, $\eta_p^2 = .84$; viewing time $F(2, 49) = 261.07$, $p < .001$, $\eta_p^2 = .90$), in which the face region attracted the highest proportion of fixations and viewing time, followed by the upper-body, waist-hip region, and then the limbs (Bonferroni post-hoc tests all *ps* < .03; Table 2 and Figure 1).

[TABLE 2 & FIGURE 1 HERE]

The participants' gender and their preference also had a significant impact on fixation (gender $F(1, 28) = 11.1$, $p < .002$, $\eta_p^2 = .28$; preference $F(1, 28) = 5.08$, $p < .03$, $\eta_p^2 = .15$) and viewing time distribution (gender $F(1, 28) = 5.19$, $p < .03$, $\eta_p^2 = .16$; preference $F(1, 28) = 4.78$, $p < .04$, $\eta_p^2 = .15$) when exploring the figures, suggesting men and women employed different gaze patterns in viewing preferred and non-preferred figures. The clear interaction between participants' gender, their preferences and figure regions (fixation $F(3, 78) = 24.25$, $p < .001$, $\eta_p^2 = .46$; viewing time $F(2, 54) = 24.66$, $p < .001$, $\eta_p^2 = .47$) further indicated that such differential gaze pattern could be reflected by different fixation and viewing time allocation to different figure regions.

Planned comparisons were used to compare men and women viewing the same figure region of their preferred gender figure (e.g., men viewing the upper-body of female figures and women viewing the upper-body of male figures). It was evident that in relation to participant gender, when exploring images of their preferred gender, women dedicated more fixations and longer viewing time to the face region than men ($p < .04$), whereas men directed more attention to the upper-body ($p < .001$) and waist-hip of their preferred image ($p < .008$) than women. In contrast, while viewing their non-preferred figures, women allocated more gaze to the upper-body and waist-hip regions than men ($p < .02$), whereas men looked more often at the limbs than women ($p < .05$).

In relation to gender preference, compared with non-preferred images, men directed significantly less attention to the face ($p < .02$) and limbs area ($p < .04$), but significantly more fixations and longer viewing time to the upper body ($p < .002$) and waist-hip region ($p < .01$) of preferred figures. For women, the trend was reversed. They dedicated more attention to the face ($p < .01$) and limbs region ($p < .002$), but less attention to the upper body ($p < .001$) and waist-hip region ($p < .006$) of preferred images. It seems that men and women tend to adopt distinctly different and almost opposite gaze strategies in viewing figures of preferred and non-preferred gender, possibly to facilitate the process of sampling visual information related to sexual preference.

Relationship of gender- and preference-related gaze strategy to the age of viewed figures

The above analysis revealed that exploring figures of preferred age could induce a gaze pattern which is sensitive to viewers' gender and their preference of image gender. To assess whether this participant gender- and preference-sensitive gaze pattern reflects a generic oculomotor strategy in viewing the opposite sex or a more specific oculomotor strategy in viewing sexually preferred figures, we examined participants' gaze patterns in viewing figures of different age groups (baby, 10-year-old, 20-year-old, 40-year-old and 60-year-old).

Two 2 (participant gender) × 2 (gender preference) × 5 (age group) × 4 (figure regions) ANOVAS with proportion of fixations and viewing time allocated at each figure region as dependent variables revealed significant main effects of participant gender, age group, and figure regions (all *ps* < .05), suggesting that gaze allocation in figure viewing was influenced by participant gender and age of viewed figures (i.e. the face area in 20-

year-old tends to attract a lower proportion of fixations and viewing time in comparison with the face area in babies and 60-year-old). Furthermore, irrespective of viewed figure, in comparison with other figure regions, a disproportionate amount of fixation/viewing time was always directed at the face area (Figure 1).

We then focused our analysis on the comparison of gaze patterns induced by the male and female figures within the same age group. There was a clear interaction between participant gender, gender preference, figure age group, and figure regions on fixation distribution ($F(7, 188) = 10.44$, $p < .001$, $\eta_p^2 = .19$) and viewing time distribution ($F(7, 187) = 6.68$, $p < .001$, $\eta_p^2 = .27$), suggesting that differential gaze patterns towards 20-year-old preferred and non-preferred figures were not consistent across all age groups (Figure 1). Further planned comparisons demonstrated that except for 20-year-old figures, men directed indistinguishable amount of fixations and viewing time towards the female and male upper-body or waist-hip regions of other aged images ($p > .05$), and dedicated more viewing to the 20-year-old female upper-body and waist-hip regions than any other female images ($p < .001$). It seems that compared with non-preferred figures, the increased gaze allocation towards the upper-body and waist-hip of preferred figures is unique to 20-year-old images for men, further indicating that men's gaze behavior to figures may reflect their sexual preference.

In contrast to men, the gaze allocation to preferred and non-preferred figures from women viewers was less specific and less age-sensitive. They demonstrated different gaze distribution at the upper-body area of preferred and non-preferred figures for all adult (20, 40 and 60-year-old) image categories; in all cases more fixations and longer viewing time were directed towards the non-preferred female upper body ($p < .005$). For the waist-hip region, slightly more gaze was dedicated to the 60-year-old male (preferred) figures and 10-year-old female (non-preferred) figures compared with the opposite figure gender ($p < .02$).

Influence of low-level image salience

Our analysis revealed that both men and women directed differential patterns of gaze distribution to male and female figures. Specifically, men showed an increased proportion of fixations and viewing time towards the upper-body and waist-hip regions only when they viewed female figures of their preferred age. It could be argued that the differences in gaze allocation to relevant figure region across image categories were driven by low-level image salience (i.e. local image contrast, intensity and structure) rather than top-down processes, such as sexual interest. To examine this possibility, we calculated the top ten salient regions within each image using the most widely used saliency model of Itti and Koch (2000), with the authors' original parameters and implementation (obtained from http://ilab.usc.edu). This procedure was conducted for each of the fifty images. The model compares local image intensity, colour and orientation, combines them into a single saliency map, and then produces a sequence of predicted fixations that scan the scene in order of decreasing saliency. We chose to calculate the first ten salient regions within the image because our participants on average made 10 fixations per image in figure viewing. The salient regions were defined as all points within 2° of the salient midpoint indicated by the model (2º is considered an average estimate of foveal size) (Foulsham & Underwood, 2008; Tatler & Vincent, 2009).

The procedure for analysing real fixation distributions was then employed to analyse the distribution of salient regions (predicted fixations) within the figure. Briefly, for each image, the predicted fixations were grouped together according to their locations within defined figure features (face, upper-body, waist-hip and limbs). The number of predicted fixations within each figure feature was normalised to the total number of predicted fixations. Finally, the proportion of the area of a particular figure feature relative to the whole image was subtracted from the proportion of predicted fixations allocated at that figure feature.

A 2 (figure gender) × 4 (figure regions) × 5 (age group) ANOVA with proportion of predicted fixations within each figure region as dependent variables revealed no significant main effect of figure gender and age, and no significant interaction of Figure Gender × Age, Figure Gender × Figure Region × Age (all *ps* > .13). Clearly, for each individual figure feature, its saliency was consistent across all image categories.

To further determine to what extent local image saliency could account for real fixations, we directly compared the proportion of predicted and real fixations allocated to each figure feature for all the images. A 2 (predicted vs real fixations) × 4 (figure regions) ANOVA demonstrated a significant interaction effect ($F(2, 240) = 50.9$, $p < .001$, $\eta_p^2 = .34$; Figure 2), suggesting the amount of fixations directed at individual figure region by the viewers was different to those predicted by local image saliency. Planned comparisons further revealed that participants allocated more fixations to the face ($p < .001$), upper-body ($p < .004$) and waist-hip ($p < .001$) than predicted, but less to the limbs ($p < .001$).

[FIGURE 2 HERE]

Considering the differences in exact location between predicted and real fixations, our saliency analysis overestimated the predictive power of local image saliency. For instance, up to 90% of the predicted fixations were located on or close to the edge of a figure feature, whereas real fixations tended to lie on the central part of the figure region. Thus, although the predicted and real fixation may be in the same figure region, they are likely to be located at different parts of this region. Consistent with previous studies that local image saliency cannot account for fixations to people in real world scenes (Birmingham, Bischof & Kingstone, 2009), our analysis indicated that differential gaze patterns towards preferred and non-preferred figure images could not accounted for by low-level image salience.

Contribution of image attractiveness

To examine whether image attractiveness could be associated with distinct gaze pattern towards preferred and non-preferred figures, we recruited another 30 undergraduate participants (15 men and 15 women, white, heterosexual and of British origin aged between 19-23 years (M = 19.78 years, SD = 1.02)). These 30 participants and the participants reported in the above studies were from the same academic department. Participants were asked to rate how attractive they found each figure on a 7-point Likert scale, with 7 representing 'very attractive' and 1 representing 'very unattractive'. Given the ethical issues involved in rating 'sexual' attractiveness of baby and child figures, participants were simply asked to rate how generally attractive they found each image. Scores for each image are listed in Table 3. A Friedman analysis showed no significant differences in the attractiveness of the five exemplars for each image type (all *ps* > .05), suggesting the five image examples belonging to the same figure gender and age appeared equally attractive to our viewers.

[TABLE 3 HERE]

A 2 (participant gender) × 2 (gender preference) × 5 (age group) ANOVA with average rating of image as the dependent variable revealed a significant main effect of age ($F(2, 53) = 73.41$, $p < .001$, $\eta_p^2 = .72$), in which the 20-year-old images received the highest rating, followed by the 40-year-old, and then the 10-year-old and the babies. Sixty-year-old images, on the other hand, were rated the least attractive (Table 3). Attractiveness ratings were also significantly affected by participant gender ($F(1, 28) = 19.87$, $p < .001$, $\eta_p^2 = .42$) and their preference for image gender ($F(1, 28) = 58.59$, $p < .001$, $\eta_p^2 = .67$); women tended to rate figures in all age groups as more attractive than men, and the female figures of 10, 20 and 40-year-olds were rated more attractive than their male counterparts (all *ps* < .01).

A clear interaction between the three independent variables ($F(3, 63) = 42.79$, $p < .001$, $\eta_p^2 = .60$) further suggested that the gender of image affected attractiveness ratings for men and women but only for certain age groups. Planned comparisons revealed that when judging 20-year-old figures, both men and women rated figures of their preferred gender as more attractive than those of their non-preferred gender ($p < .04$, Figure 3); men also judged 40-year-old female figures more attractive than 40-year-old male figures ($p < .04$) .

[FIGURE 3 HERE]

Although different groups of participants were recruited for the eye-tracking and attractiveness rating studies, there was a strong correlation between the two measurements. For instance, the figures with age (20-year-old) and gender matching our participants' preference were rated as the most attractive, and they attracted the highest number of fixations and different gaze distributions (more evident for men). The oldest and youngest figures, on the other hand, were judged as the least attractive and attracted the least number of fixations irrespective of image gender (see Tables 1 and 3). Taken together, gaze distribution in figure viewing could reflect the assessment of body attractiveness, as least for men.

Discussion

Motivated by the suggestion that our gaze behavior in viewing scenes of high ecological validity is guided by interest (Henderson, 2003; Issacowitz, 2006) and implicated in preference formation (Shimojo et al., 2003), here we demonstrated that young, heterosexual men adopted a distinctive gaze pattern when viewing 20-year-old female figures. Significantly more fixations and longer viewing time were directed at figure regions considered informative for fertility and sexual attraction, such as the upper body and waist-hip region (Singh & Young, 1995). This gaze behavior was not replicated with images of females of other age groups or with images of males, suggesting that the men's viewing pattern to human figures could be linked with their sexual preference.

A few recent studies also observed that heterosexual men directed more visual attention to opposite sex figures in both erotic and non erotic stimuli (Lykins et al., 2006, 2008; Rupp & Wallen, 2007). However, some of these studies used relatively crude measures to define where the observer was viewing (i.e., face, body, genitals, background) (Lykins et al., 2006, 2008; Rupp & Wallen, 2007), offering little insight into which body regions were crucial in this visual assessment. Other researchers did not compare viewing strategies to different aged figure images (Hewig et al., 2008) or gender (Cornelissen et al., 2009). This limits their ability to demonstrate whether this viewing strategy reflects a more generic gender-specific strategy or is specific to viewing sexual targets (i.e. age and gender appropriate). Our study is the first to demonstrate that differentiated gaze pattern in viewing male and female figures was localised in regions crucial for sexual arousal, and was age-specific, which is consistent with the notion that age is particularly important for men when choosing a mate (Menken, Trussell, & Larsen, 1986). It is likely, therefore, that our male participants engaged a unique cognitive process to assess mate value while viewing 20-year-old females. Such a process, even with a free viewing task, could be manifested in their distinctive gaze patterns with increased attention to the upper body and waist-hip regions. Given that observers directed more fixations to these two regions than predicted by a saliency-map technique (see Figure 2), clearly low-level image properties could not account for this observation, suggesting that bottom-up processes have limited impact when assessing figures.

Women did not show a unique gaze pattern towards 20-year-old male images. On the contrary, they tended to direct more fixation and longer viewing time to the upper body and/or waist-hip region of sexually developed females, especially for those of 20-year-old, which may serve frequently-engaged processes of body comparison (Lykins et al., 2008) and emphasis on other women's physical appearance (Fisher, 2004).

Our findings are consistent with previous research showing heterosexual women do not demonstrate as strong a visual preference to opposite sex figures as do heterosexual men, with past findings demonstrating women show more viewing to the same-sex figure than men (Israel & Strassberg, 2009; Lykins et al., 2008) and indeed look as much at the female figure as men (Rupp & Wallen, 2007). Building on this, our findings illustrate that when viewing same-sex figures, women are attending to the same figure regions as men; however, unlike men, women employ this gaze strategy regardless of the age of the viewed figure, supporting a lack of specificity in women's gaze pattern while exploring sexually preferred and non-preferred figures.

In general, our findings are in agreement with previously observed gender differences in arousal. Heterosexual men have consistently been found to report more genital and subjective arousal to their preferred gender (Chivers & Bailey, 2005; Chivers, Reiger, Latty, & Bailey, 2004) and age (Blanchard, Klassen, Dickey, Kubam, & Blak, 2001; Seto, Lalumiere, & Blanchard, 2000). Heterosexual women, on the other hand, reported genital and subjective arousal to same-sex stimuli (Chivers & Bailey, 2005; Chivers et al., 2004; Chivers, Seto, & Blanchard, 2007). Thus, our observed gender differences in gaze strategy techniques may reflect organisational differences in sexual arousal, with men's arousal dependent upon stimulus-specific features, and women's genital arousal a more automatic response to stimuli categorised as 'sexual,' although not necessarily consistent with their subjective arousal (Chivers & Bailey, 2005). Our results may also be taken to support previous findings that demonstrate heterosexual women are more likely to engage in same-sex activity than heterosexual men (Baumeister, 2000).

Additionally, our results may reflect differences in men and women's pre-occupation with sex. It is often reported that men experience more sexual desire (Regan & Atkins, 2006), engage in more sexual practices (Laumann, Gagnon, Michael, & Michaels, 1994) and report more interest in sexual stimuli than women (Janssen, Carpenter, & Graham, 2003). As such, whereas our male participants may have been viewing the figures for sexual interest, our women may have been using another strategy unrelated to sexual interest (for example, body comparison).

It could be argued that the increased proportion of fixations directed to the waist-hip region of 20-year-old females is due to this region being more distinct at this age than any other. Although it is difficult to control for this variable in realistic figure images, our analysis of local image saliency (including local image curvature) indicated that the number of predicted fixations directed at the female waist-hip region was indistinguishable across the five age categories. Therefore, it is unlikely that visual distinctiveness of the waist-hip region in young female figures could solely account for this increase in gaze distribution. Recent gaze pattern studies in face or body perception also suggest that local image regions with high image salience (based on the calculation of local image physical properties) are not correlated with the gaze distribution in viewing images with high biological relevance (Birmingham et al., 2009; Dahl et al., 2009; Guo et al., 2010) (also see our analysis in Figure 2). Hence the gaze distribution within a human figure is more likely to be dependent upon the amount of available task-relevant information contained within each figure region, rather than constrained by their simple physical properties.

Although due to our relatively small sample size we cannot generalise these findings to a broader population, the results show supportive evidence for eye-tracking as a measure of sexual interest. As this was an initial, exploratory study we controlled for potential confounds such as age, race, and culture. For women we also controlled for potential influence of menstrual cycle on gaze behavior in viewing images of sexual interest, thus we cannot generalise our results to normally ovulating women. Future studies may wish to build upon our findings by investigating for differences in a more varied population.

Men showed a distinct and sexual attraction assessment-related gaze pattern while viewing figures of their reported sexual interest (women) in their age range (20-year-old), suggesting gaze pattern in men could reflect their sexual preference explicitly. Our current findings indicate that gaze behaviour to clothed figures is a promising methodology for the assessment of male sexual interest; it will be intriguing to extend this study to other men with different sexual orientation, and correlate their gaze behavior with other measurements of sexual preference (e.g. phallometric assessment, self report).

References

Baumeister, R. F. (2000). Gender differences in erotic plasticity: The female sex drive as socially flexible and responsive. *Psychological Bulletin, 126,* 347-374.

Birmingham, E., Bischof, W. F., & Kingstone, A. (2009). Saliency does not account for fixations to eyes within social scenes. *Vision Research, 49,* 2992-3000.

Blanchard, R., Klassen, P., Dickey, R., Kubam M. E., & Blak, T. (2001). Sensitivity and specificity of the phallometric test for paedophilia in non-admitting sex offenders. *Psychological Assessment, 13,* 118-126.

Chivers, M. L., & Bailey, J. M. (2005). A sex difference in features that elicit genital response. *Biological Psychology, 70*, 115-120.

Chivers, M. L., Reiger, G., Latty, E., & Bailey, J. M. (2004). A sex difference in the specificity of sexual arousal. *Psychological Science, 15*, 736-744.

Chivers, M. L., Seto, M. C., & Blanchard, R. (2007). Gender and sexual orientation differences in sexual response to sexual activities versus gender of actors in sexual films. *Journal of Personality and Social Psychology, 93,* 1108-1121.

Cornelissen, P. L., Hancock, P. J. B., Kiviniemi, V., George, H. R., & Tovee, M. J. (2009). Patterns of eye-movements when male and female observers judge female attractiveness, body fat and waist-to-hip ratio. *Evolution and Human Behavior, 30,* 417-428.

Dahl, C. D., Wallraven, C., Bulthoff, H. H., & Logothetis, N. K. (2009). Humans and macaques employ similar face-processing strategies. *Current Biology, 19,* 509-513.

Fisher, M. F. (2004). Female intrasexual competition decreases female facial attractiveness. *Proceedings of the Royal Society of London - Series B: Biological Sciences, 271,* 283- 285.

Flak, V., Beech, A., & Fisher, D. (2007). Forensic assessment of deviant sexual interests: the current position. *Issues in Forensic Psychology, 6,* 70-83.

Foulsham, T., & Underwood, G. (2008). What can saliency models predict about eye movements? Spatial and sequential aspects of fixations during encoding and recognition. *Journal of Vision, 8,* 1-17.

Guo, K., Mahmoodi, S., Robertson, R. G., & Young, M. P. (2006). Longer fixation duration while viewing face images. *Experimental Brain Research, 171*, 91-98.

Guo, K., Tunnicliffe, D., & Roebuck, H. (2010). Human spontaneous gaze patterns in viewing of faces of different species. *Perception, 39,* 533-542.

Hanson, R. K., & Morton-Bourgon, K. (2005). The characteristics of persistent sexual offenders: A meta-analysis of recidivism studies. *Journal of Consulting and Clinical Psychology*, 73, 1154–1163.

Henderson, J. M. (2003). Human gaze control during real-world scene perception. *Trends in Cognitive Science, 7,* 498 – 504.

Hewig, J., Trippe, R. H., Hecht, H., Straube., T., & Miltner. W. H. R. (2008). Gender differences in specific body regions when looking at men and women. *Journal of Nonverbal Behavior, 32,* 67-78.

Isaacowitz, D. M. (2006). Motivated gaze: the view from the gazer. *Current Directions in Psychological Science, 15,* 68-72.

Israel, E., & Strassberg, D. S. (2009). Viewing time as an objective measure of sexual interest in heterosexual men and women. *Archives of Sexual Behavior,* 38, 551-558.

Itti, L., & Koch, C. (2000). A saliency-based search mechanism for overt and covert shifts of visual attention. *Vision Research, 40,* 1489-1506.

Janssen, E., Carpenter, D., & Graham, C. (2003). Selecting film clips for sex research: Gender differences in erotic film preference. *Archives of Sexual Behavior, 32,* 243-251.

Kalmus, E., & Beech, A. R. (2005). Forensic assessment of sexual interest: A review. *Aggression and Violent Behavior, 10,* 193-217.

Laumann, E., Gagnon, J. H., Michael, R. T., & Michaels, S. (1994). *The social organization of sexuality: sexual practices in the United States*. Chicago: University of Chicago.

Lykins, A. D., Meana, M., & Kambe, G. (2006). Detection of differential viewing patterns to erotic and non-erotic stimuli using eye-tracking methodology. *Archives of Sexual Behavior, 35,* 569-575.

Lykins, A. D., Meana, M., & Strauss, G. P. (2008). Sex differences in visual attention to erotic and non-erotic stimuli. *Archives of Sexual Behavior, 37,* 219-228.

Menken, J. J., Trussell, J., & Larsen, U. (1986). Age and infertility, *Science, 233,* 1389-1394.

Nummenmaa, L., Hyona, J., & Calvo, M. G. (2006). Eye movement assessment of selective attentional capture of emotional pictures. *Emotion, 6,* 257-268.

Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin, 124,* 372-422.

Regan, P. C., & Atkins, L. (2006). Sex differences and similarities in frequency and intensity of sexual desire. *Social Behavior and Personality, 34,* 95-102.

Rupp, H. A., & Wallen, K. (2007). Sex differences in viewing sexual stimuli: An eye-tracking study in men and women. *Hormones and Behavior, 51,* 524-533.

Seto, M. C., Lalumiere, M. L., & Blanchard, R. (2000). The discriminative validity of a phallometric test for pedophilic interests among adolescent sex offenders against children. *Psychological Assessment, 12,* 319-327.

Shimojo, S., Simion, C., Shimojo, E., & Scheier, C. (2003). Gaze bias both reflects and influences preference. *Nature Neuroscience*, 6, 1317-1322.

Singh, D., & Young, R. K. (1995). Body weight, waist-to-hip ratio, breasts and hips: Role in judgments of female attractiveness and desirability for relationships. *Ethology and Sociobiology, 16,* 483-507.

Suschinsky, K. D., Elias, L. J., & Krupp, D. B. (2007). Looking for Ms. Right: Allocating attention to facilitate mate choice decisions. *Evolutionary Psychology, 5,* 428-441.

Tatler, B. W., & Vincent, B. T. (2009). The prominence of behavioral biases in eye guidance. *Visual Cognition, 17,* 1029-1054.

Tooke, W., & Camire, L. (1991). Patterns of deception in intersexual and intrasexual mating strategies. *Ethology and Sociobiology, 12,* 345-364.

Table 1

Averaged Number of Fixations Male and Female Viewers Dedicated to Preferred and Non-Preferred Gender Images for Baby, 10-year-old, 20-year-old, 40-year-old, and 60-year-old Images

Image Category	Male Viewers		Female Viewers	
	Female Images	Male Images	Female Images	Male Images
Babies	9.2 (3.0)	9.2 (2.9)	9.2 (2.3)	8.7 (2.0)
10 year-olds	8.7 (2.8)	10.2 (2.8)	10.4 (1.6)	9.9 (2.6)
20 year-olds	10.4 (2.8)	10.2 (2.6)	10.6 (2.1)	10.4 (1.7)
40 year-olds	9.6 (3.2)	9.7 (3.5)	10.2 (2.1)	9.3 (2.2)
60 year-olds	8.9 (3.2)	8.9 (3.2)	9.6 (2.0)	8.7 (1.6)

Note. Standard deviations of the mean are given in parentheses.

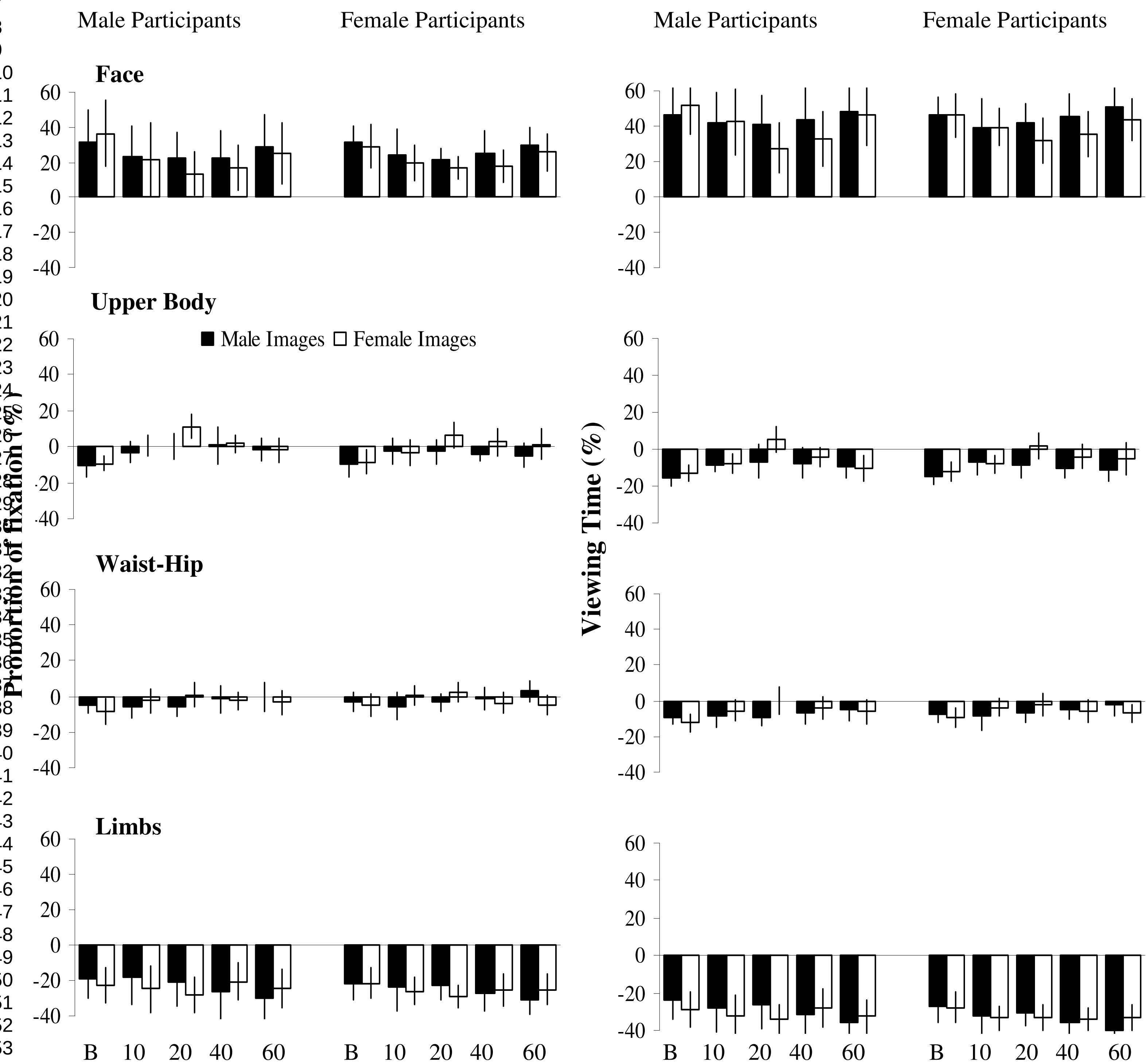
Table 2

Proportion of Normalized Fixations and Viewing Time Directed at the Face, Upper Body, Waist-Hip and Limbs of Preferred Gender and Non-Preferred Gender Images by Male and Female Viewers

		Proportion of Fixations (%)		Viewing Time (%)	
Gender of Viewer	Body Region	Preferred	Non-Preferred	Preferred	Non-Preferred
Male	Face	13.5 (12.3)	22.8 (13.9)	27.6 (14)	40.7 (17)
	Upper-Body	11.2 (6.4)	0.2 (7.2)	5.1 (6.8)	-6.7 (9.3)
	Waist-Hip	0.8 (7.0)	-5.8 (5.5)	0.08 (7.5)	-9.3 (4.3)
	Limbs	-28.4 (9.7)	-20.5 (13.7)	-34.4 (8.5)	-26.6 (12.4)
Female	Face	21.4 (6.0)	16.8 (6.1)	42.1 (11)	31.5 (12.7)
	Upper-Body	-2.8 (6.7)	6.8 (7.1)	-8.9 (6.4)	1.9 (7.1)
	Waist-Hip	-3.3 (4.9)	2.1 (5.7)	-6.9 (5.6)	-2.3 (6.6)
	Limbs	-22.4 (8.5)	-28.9 (6.3)	-30.8 (6.4)	-32.9 (6.7)

Note. Standard deviations of the mean are given in parentheses.

Figure 1



Male Participants
Female Participants
Male Participants
Female Participants
Face
Upper Body
Male Images
Female Images
Waist-Hip
Limbs
Proportion of fixation (%)
Viewing Time (%)
60
40
20
0
-20
-40
B
10
20
40
60

Figure 2

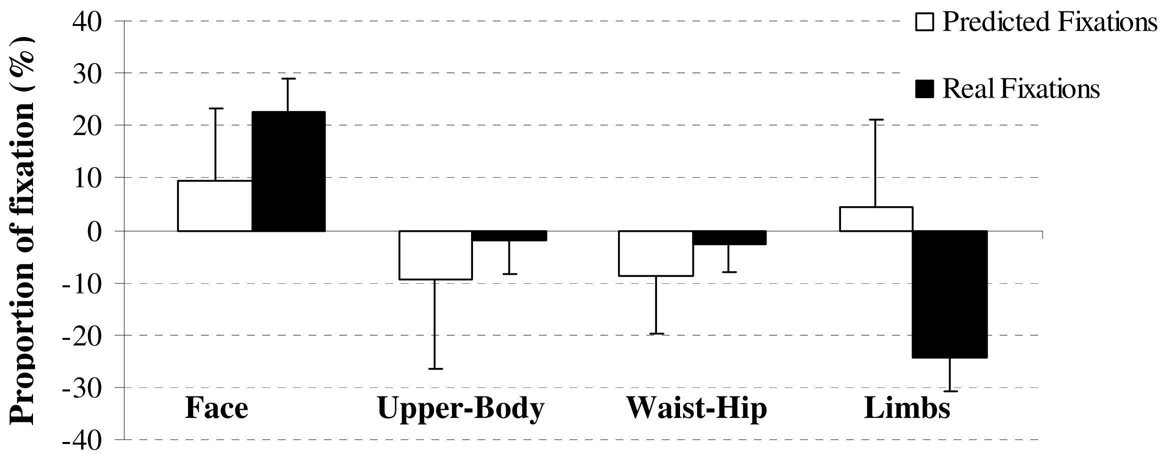

40
30
20
10
0
-10
-20
-30
-40
Proportion of fixation (%)
Predicted Fixations
Real Fixations
Face
Upper-Body
Waist-Hip
Limbs

Table 3

Average Attractiveness Ratings for Each Body Image Obtained From a Sample of 15 Male and 15 Female Heterosexual Viewers

Image Category	Image Gender	Image 1	Image 2	Image 3	Image 4	Image 5
Baby	Male	2.3 (1.1)	2.3 (1.3)	2.4 (1.2)	2.2 (1.1)	2.3 (1.21)
	Female	2.2 (0.7)	2.3 (1.2)	2.3 (1.2)	2.4 (1.2)	2.3 (1.2)
10 year-olds	Male	1.9 (0.8)	1.9 (1.0)	1.9 (0.7)	1.8 (0.5)	1.9 (1.0)
	Female	2.7 (1.7)	2.1 (0.9)	2.3 (1.3)	2.7 (1.8)	2.6 (1.5)
20 year-olds	Male	3.7 (1.2)	4.0 (1.6)	3.6 (1.4)	3.9 (1.4)	3.7 (1.3)
	Female	5.4 (1.4)	5.4 (1.2)	5.2 (1.9)	5.2 (1.2)	5.3 (1.1)
40 year-olds	Male	2.5 (1.2)	2.4 (0.9)	2.7 (1.1)	2.9 (1.2)	2.6 (1.1)
	Female	3.8 (1.6)	4.3 (1.4)	4.3 (2.0)	3.8 (1.3)	4.1 (1.3)
60 year-olds	Male	1.5 (1.5)	1.3 (0.5)	1.3 (0.5)	1.3 (0.3)	1.2 (0.4)
	Female	1.4 (0.4)	1.3 (0.5)	1.5 (0.4)	1.4 (0.6)	1.3 (0.4)

Note. Standard deviations of the mean are given in parentheses.

Figure 3

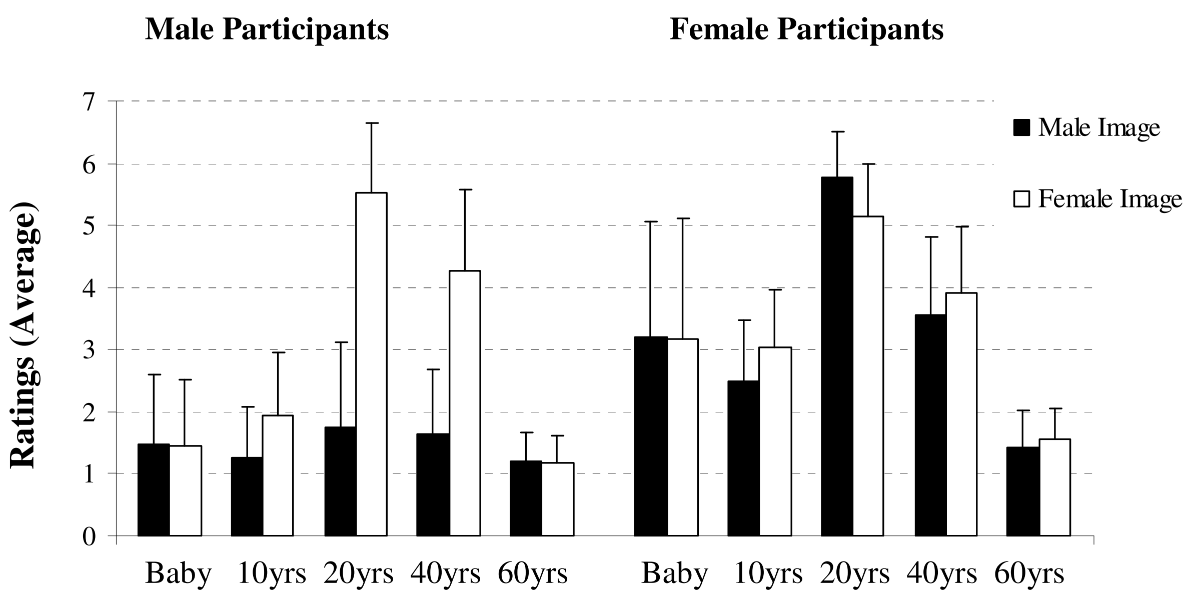

Male Participants
Female Participants
Ratings (Average)
7
6
5
4
3
2
1
0
Baby
10yrs
20yrs
40yrs
60yrs
Baby
10yrs
20yrs
40yrs
60yrs
Male Image
Female Image

Figure Captions

Figure 1. Proportion of normalized fixations (left) and viewing time (right) measured to the face, upper body, waist-hip and limbs of male *(black columns)* and female *(white columns)* babies (*B)*, pre-pubescent children 10-years-old (*10*), adults in their early 20's (*20*), adults in their late 30's or early 40's (*40*) and adults in their 60's (*60*). Results from male participants' are represented on the left side of each graph; results from female participants' are on the right. *Error bars* indicate standard deviation of mean.

Figure 2. Proportion of fixations to the four figure regions (face, upper-body, waist-hip and limbs) as predicted by the saliency map and average of all participant data. *Error Bars* indicate standard deviation of mean.

Figure 3. Male and female participants' ratings of attractiveness for male and female images of five ages (baby, 10 year-olds, 20 year-olds, 40 year-olds, 60 year-olds). *Error Bars* indicate standard deviation of mean.