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ORIGINAL PAPER

Gender and Visibility of Sexual Cues Influence Eye Movements While Viewing Faces and Bodies

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Abstract Faces and bodies convey important information for the identification of potential sexual partners, yet clothing typically covers many of the bodily cues relevant for mating and reproduction. In this eye tracking study, we assessed how men and women viewed nude and clothed, same and opposite gender human figures. We found that participants inspected the nude bodies more thoroughly. First fixations landed almost always on the face, but were subsequently followed by viewing of the chest and pelvic regions. When viewing nude images, fixations were biased away from the face towards the chest and pelvic regions. Fixating these regions was also associated with elevated physiological arousal. Overall, men spent more time looking at female than male stimuli, whereas women looked equally long at male and female stimuli. In comparison to women, men spent relatively more time looking at the chests of nude female stimuli whereas women spent more time looking at the pelvic/genital region of male stimuli. We propose that the augmented and gender-contingent visual scanning of nude bodies reflects selective engagement of the visual attention circuits upon perception of signals relevant to choosing a sexual partner, which supports mating and reproduction.

Keywords Eye movements · Body · Nudity · Visual attention · Sexuality · Mate choice

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Introduction

Human behavior is markedly influenced by the communicative signals conveyed by our conspecifics. Numerous studies suggest that specialized neurocognitive mechanisms process the facial and bodily features that guide our social interaction and interpersonal relationships (Hari & Kujala, 2009; Haxby, Hoffman, & Gobbini, 2000; Minnebusch & Daum, 2009). Information from faces and bodies is also important for human sexual behavior. Although identification of mating partners in primates relies extensively on the visual system (Ghazanfar & Santos, 2004), evidence on the visual and attentional processes involved in detect ing sexual cues from human bodies has remained elusive. In the present eye tracking study, we demonstrate that observer and stimulus gender, as well as visibility of sexual cues, influence the visual sampling of human bodies, and discuss how this facilitated processing of nude figures may support the identification of potential sexual partners.

Numerous studies have shown that both facial and bodily cues are reliable markers of gender, health, and fertility. Waist-to-hip ratio (WHR) signals health in both genders (Pouliot et al., 1994); in women it is associated with fertility (Singh, 1993).

Facial features, including symmetry, attractiveness, and sexual dimorphism, are also potential cues to health and fitness (Rhodes, 2006). Efficient perception of such cues thus enables immediate categorization of conspecifics as potential mating partners (opposite-gender) or competitors (same-gender), and subsequently when a potential mating partner is detected, the assessment of his or her mate value. Humans and other primates display highly selective preferences for viewing the sexually relevant signals of conspecifics (Deaner, Khera, & Platt, 2005; Grammer, Fink, Moller, & Thornhill, 2003). When these signals are perceived and evaluated as positive by the emotion circuit, a physiological arousal response is elicited. This can subsequently trigger sexual behaviors and ultimately copulation (Walen & Roth, 1987). It could thus be assumed that detection of sexual cues would be facilitated across various processing stages in the brain in order to facilitate sexual selection.

Neuroimaging studies have established that a specialized brain network spanning the occipital and temporal cortices subserves perception of bodies in humans (de Gelder et al., 2010; Minnebusch & Daum, 2009; Peelen & Downing, 2007). Although this network mainly codes the configuration of human bodies, functional imaging studies have demonstrated that responses in subcomponents of this network are further amplified when participants are presented with nude human figures (Bocher et al., 2001; Schiffer et al., 2008). Interestingly, such modulation of body processing by sexual cues begins remarkably early, as confirmed by studies measuring event-related potentials. These studies have found that the body-sensitive temporocortical regions show enhanced responses towards pictures involving nude versus clothed humans already at 150–170 ms after stimulus presentation (Costa, Braun, & Birbaumer, 2003; Hietanen & Nummenmaa, 2011), suggesting very early visual categorization of potential sexual partners.

Although clothing provides cues to gender, sexual status and rank in many cultures, Western clothing typically restricts the visibility of the body, especially the primary and secondary sexual characteristics. Earliest recorded signs of clothing date to 36,000 BCE (Kvavadze et al., 2009), although genetic and molecular clock estimates of head and body lice—the latter having little chance of surviving on naked human body—suggest that body lice have originated already $72{,}000 \pm 42{,}000$ years ago, which could coincide with the beginning of frequent use of clothing (Kittler, Kayser, & Stoneking, 2003). Considering that the use of clothing as a cultural habit is relatively recent in the time-scale of evolution, it is likely that the visual and attentional systems would still be tuned to processing of nude rather than clothed bodies, and that this tuning would be reflected in the way we move our eyes when viewing human bodies with and without clothing.

Several lines of evidence support this hypothesis. First, it has been proposed that color vision might have evolved in primates for discriminating the spectral modulations on the skin of conspecifics (Changizi, Zhang, & Shimojo, 2006), and in line with this the human visual system has been found to be particularly sensitive to detecting desaturated reddish targets resembling human skin tones (Lindsey et al., 2010). Second, when viewing complex, explicitly sexual scenes with nude figures (e.g., those involving foreplay), observers land more fixations on bodies rather than on faces but this effect is reversed for scenes involving clothed figures (Lykins, Meana, & Kambe, 2006). When viewing fully clothed bodies, males tend to fixate the chest area earlier than women (Hewig, Trippe, Hecht, Straube, & Miltner, 2008); one study even found that nude female chests would typically receive the very first fixation of male observers, potentially reflecting the tendency to evaluate the attractiveness or reproductive fitness of the body (Dixson, Grimshaw, Linklater, & Dixson, 2009). Third, nude bodies have been reported to capture visual attention. Nude but not clothed human bodies elicit the attentional blink response (Most, Smith, Cooter, Levy, & Zald, 2007) traditionally assumed to reflect involuntary attention capture; moreover, orienting of attention towards one's sexually preferred versus non-preferred gender is facilitated even when the stimuli are presented outside of visual awareness (Jiang, Costello, Fang, Huang, & He, 2006), suggesting automated processing of sexual signals.

The Present Study

In sum, there is evidence that the human visual system is biased towards processing of nude human figures and that clothing might bias the visual processing of the bodily image embedded in complex sexual scenes. However, controlled eye movement studies exploring how human observers sample sexual information from same and opposite gender bodies are practically nonexistent. In the present eye tracking study, we aimed at filling this gap by answering two critical questions: First, we wanted to address whether covering the cues relevant to sexual selection by clothes would influence the visual scanning of the body and the face areas. Second, we wanted to evaluate whether viewing of the bodily image would be influenced by the gender of the participant as well as of the person shown in the images. To accomplish these aims, we employed high-resolution eye tracking while participants were viewing singly presented, nude or clothed bodies of same or opposite-gender individuals. Free viewing of pictures with no structured social or cognitive task was used to simulate naturally occurring encounters. We measured where, in which order, and for how long participants looked while inspecting the figures.

On the basis of evolutionary considerations, we predicted that humans would automatically focus their attention on the regions that provide reliable information about conspecifics' social intentions (i.e., face) as well as reproductive fit (i.e., face, chest, and pelvic region). We also predicted that observers would show preferential attention towards the opposite versus same-sex bodies. Finally, as both bodies and faces relay information relative to sexual selection but clothing effectively covers all the bodily cues, we predicted that faces would be predominantly fixated when the stimuli are clothed, whereas chest and pelvic regions would receive substantially more fixations when the stimuli are presented naked.

Experiment 1

Method

Participants

A total of 30 male undergraduate psychology students with a mean age of 21 years from the University Turku participated in the experiment and were compensated with movie tickets. In this and the following experiment, all the participants gave informed consent and had normal or corrected-to-normal vision. All were heterosexual according to the Sell Assessment of Sexual Orientation questionnaire scores (Sell, 1996).

Measures and Procedure

Stimuli were presented on a 21″ monitor (120 Hz refresh rate) with a 3.2 GHz Pentium IV computer. Participants' eye movements were recorded with an EyeLink 2000 eyetracker (SR Research, Mississauga, ON, Canada) connected to a 2.8 GHz Pentium IV computer. The sampling rate of the eyetracker was 1 kHz, and the spatial accuracy was better than .5°, with a .01° resolution in the pupil-tracking mode.

The stimuli (see Fig. 1 for illustrations) were 120 digital photographs of frontal poses of nude and clothed, attractive and normal-weight adult males and females (30 stimuli per category) appearing against white background. The stimulus pictures were acquired mainly from various Internet sites. Clothed stimuli wore sexually non-revealing clothing—at least a sleeved shirt and long pants/jeans, and some also wore a jacket or a coat. About 10% of the clothed stimuli had logos or emblems on their clothing, but these were equiprobable for male and female stimuli ($p > .05$ in χ^2 test). Nude stimuli clearly showed the chest and the genitals of the person. The amount of pubic hair varied, although it was typically rather modest. Penis size and turgidity also varied across nude male stimuli. None wore piercing or tattoos. Chi-square tests confirmed that across stimulus categories, there were no significant differences in the frequency of gaze direction (eye contact versus aversion) and facial expression (smiling versus not smiling) across the stimulus categories ($ps > .13$ in χ^2 test).

The size of the stimuli was 7 × 10° of visual angle at a viewing distance of 60 cm. The drift correction target was a black circle with a white center (diameter 1.5°) presented at the center of the screen. Stimuli were presented singly to the left or right visual field such that the centerpoint of the picture was aligned to an imaginary circle with a radius of 5.6°. The distance between

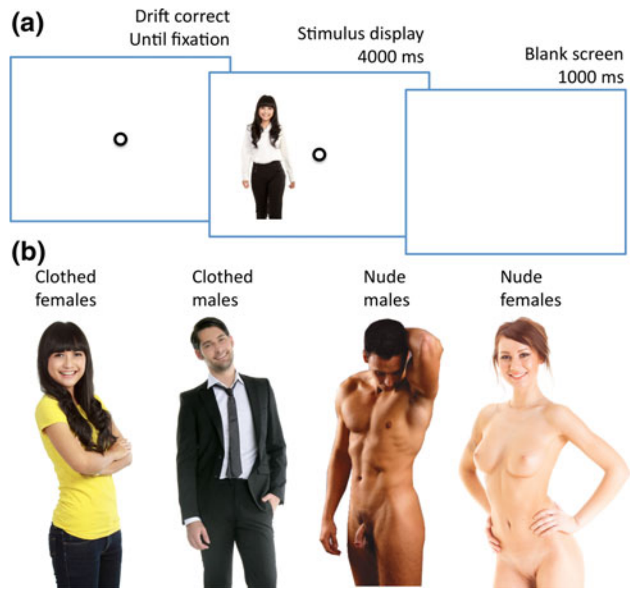

Fig. 1 Illustration of the trial events (**a**) and experimental stimuli (**b**) in Experiments 1–2

the stimulus centerpoint and horizontal axis varied between ±3.7°. This arrangement controlled for biases resulting from, for example, always performing a horizontal saccade upon picture presentation. As the stimuli were not initially in the foveal vision we could also address which stimulus regions initially captured the participants' overt attention.

The participants were told that the study concerned eye movements while viewing pictures of humans. They were explained that on each trial they were going to see a picture of a nude or clothed male or female, and that their task was to view the pictures similarly as they were viewing pictures on a computer or while reading a magazine. Next, the eyetracker was calibrated using a standard nine-point routine. The calibration was accepted if the average error was less than .5°. Each trial (see Fig. 1 for a description of the sequence of trial events) began with a drift correction. A fixation circle appeared at the center of the screen, and the participants had to focus their gaze at the center of the circle. When the participant's eye was fixated on the circle, the experimenter initiated the trial. A random delay of 0–100 ms was appended at the beginning of all trials to prevent anticipatory saccades. Next, the stimulus picture appeared randomly at the left or at the right of the fixation circle for 4 s. After an inter-trial interval of 1,000 ms, the central fixation point reappeared and the next trial was initiated. Each participant performed one block of the task with a total of 120 trials, with each stimulus shown once in a random order. The experiment was preceded by 10 practice trials. Visual field of the stimuli was counterbalanced. After the experiment, the participants rated the valence and arousal of the stimulus categories with the self-assessment manikin with scales ranging from 1 to 9 (Bradley & Lang, 1994). Valence (unpleasantness vs. pleasantness) reflects the dominant motive system activated (avoidance or approach), whereas arousal reflects the intensity of motive system activation, from calm to tension (Lang, 1995). Accordingly, this conceptualization enables an independent assessment of the likeability of targets, as well as the arousal levels they trigger.

Eye Movement Analysis Two different analytic strategies were used. The first approach was based on statistical parametric mapping of fixation heatmaps (see, e.g., Caldara, Zhou, & Miellet, 2010). Briefly, fixations were first transformed into common *xy*-originator, as the actual stimulus position was jiggled from trial to trial. Next, participant-wise fixation heatmaps for each trial type (nude males, nude females, clothed males, clothed females) were generated by modeling each fixation as a Gaussian function with *mu* of fixation's Cartesian coordinate and *sigma* of 1° (based on the assumption that the foveal field of view is roughly 2°; see Wandell, 1995) and multiplied with fixation duration in milliseconds. Mass univariate *t*-tests were then used to compare the smoothed fixation distributions across trial types (male vs. female, nude vs. clothed, nude females vs. nude males and clothed females vs. clothed males). This resulted in statistical *T*-maps where pixel intensities reflect statistical differences in fixation probabilities across conditions. Finally, False Discovery Rate (FDR) correction with an alpha level of .05 was applied to the statistical maps to control for false positives due to multiple comparisons.

As our stimulus models varied slightly in posture, the heatmap analyses were also complemented by classical region-of-interest (ROI) analyses. In this approach, rectangular ROIs were drawn around the face, chest, and pelvic-genital areas of the stimuli. Subsequently, we analyzed separately data for fixation events that occurred within or towards each ROI (for a similar approach using face stimuli, see Calvo & Nummenmaa, 2008, 2009). We computed the mean (1) *first fixation time*, that is, the latency of the first fixation landing on the area, (2) *duration of the first fixation*, (3) gaze duration (i.e., *dwell time*) for the area, and (4) average *pupil size* for fixations landing on ROI. Trial wise total fixation counts were computed to address overall attention allocation to the stimuli. Finally, latencies of the first saccades with an amplitude exceeding 2° initiated towards stimuli (irrespective of ROI) were computed to address the speed of attentional orienting towards different stimulus categories. Two-tailed alpha level of $p < .05$ was applied in all statistical analyses. Multiple comparisons were corrected using the Bonferroni procedure.

Results

Self-Report Scores

The self-reported valence and arousal scores (see Table 1) for the stimuli were analyzed with a 2 (gender) × 2 (clothing) repeated measures ANOVA. Female pictures were rated as more pleasant than male pictures, $F(1, 29) = 207.02$, $p < .001$, $\eta_p^2 = .87$, and nude pictures were rated as more pleasant than clothed pictures, $F(1, 29) = 20.01$, $p < .001$, $\eta_p^2 = .40$. The interaction of gender and clothing, $F(1, 29) = 66.80$, $p < .001$, $\eta_p^2 = .69$, showed that whereas both nude and clothed female pictures were rated as equally pleasant, $F(1, 29) = 3.53$ (ns), male pictures were rated as more pleasant when they were clothed, $F(1, 29) = 58.80$, $p < .001$, $\eta_p^2 = .66$. Analysis of arousal scores revealed that female pictures were rated as more arousing than male pictures, $F(1, 29) = 45.02$, $p < .001$, $\eta_p^2 = .60$, and nude pictures were rated as more arousing than clothed pictures, $F(1, 29) = 195.84$, $p < .001$, $\eta_p^2 = .87$. The interaction of gender and clothing, $F(1, 29) = 14.92$, $p < .001$, $\eta_p^2 = .32$, showed that removing clothes from the models resulted in a greater increase of arousal for female than male models, $F(1, 29) = 14.92$, $p < .001$, $\eta_p^2 = .32$.

Table 1 Mean valence and arousal scores for the clothed and nude male and female stimuli used in Experiments 1 and 2

	Clothed		Nude	
	M	*SD*	*M*	*SD*
Valence				
Male	5.35	1.05	3.29	1.57
Female	7.26	.89	7.65	.91
Arousal				
Male	1.42	.72	2.00	1.24
Female	4.35	1.54	6.35	1.43

Absolute range, 1–9

Fixation Heatmaps

Figure 2 shows statistically thresholded fixation density difference images overlaid on a body stimulus. These maps reveal that female stimuli were inspected in more detail than male stimuli; the statistical difference in fixation distributions was most profound in the chest and pelvic regions. Additionally, nude (vs. clothed) stimuli received more fixations in the chest and pelvic area, whereas the faces of the clothed stimuli were inspected in more detail.

Global Eye Movement Measures

The global eye movement data were analyzed with a 2 (gender) × 2 (clothing) ANOVA. Stimulus clothing, gender or their interaction did not influence latencies of the first saccade towards the pictures, $Fs < 1$. However, the number of fixations was influenced by both gender, $F(1, 29) = 17.93$, $p < .001$, $\eta_p^2 = .32$, clothing, $F(1, 29) = 33.71$, $p < .001$, $\eta_p^2 = .54$, and their interaction, $F(1, 29) = 9.89$, $p < .01$, $\eta_p^2 = .25$. More fixations were made on female than male pictures ($M_{female} = 11.82$, $M_{male} = 11.18$) and on nude than clothed pictures ($M_{nude} = 12.03$, $M_{clothed} = 10.97$). The interaction resulted from the fact that fixation frequency for male and female stimuli was equal when the bodies wore clothes, $F < 1$, whereas significantly more fixations emerged on female pictures when the stimuli were presented without clothes, $F(1, 29) = 380.39$, $p < .001$, $\eta_p^2 = .93$.

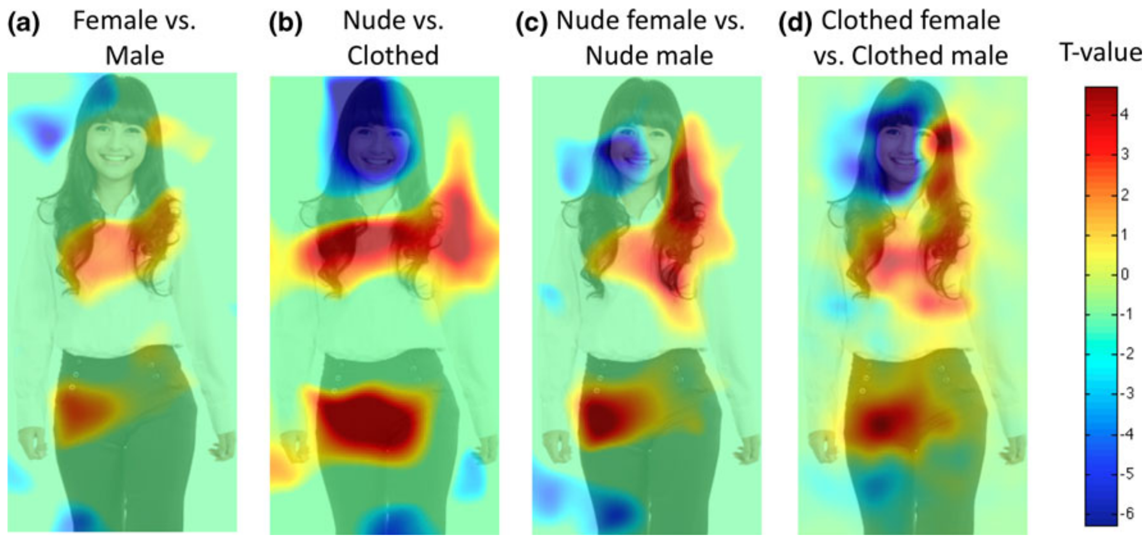

Fig. 2 Statistical *T*-maps displaying differences in fixation patterns across experimental conditions overlaid on a sample body stimulus in Experiment 1. *Yellow* to *red* codes a bias towards females (**a**, **c**, and **d**) or nude bodies (**b**), *turquoise* to *blue* codes a bias towards males (**a**, **c**, and **d**) or clothed bodies (**b**). The data are thresholded at $p < .05$ (FDR corrected for multiple comparisons)

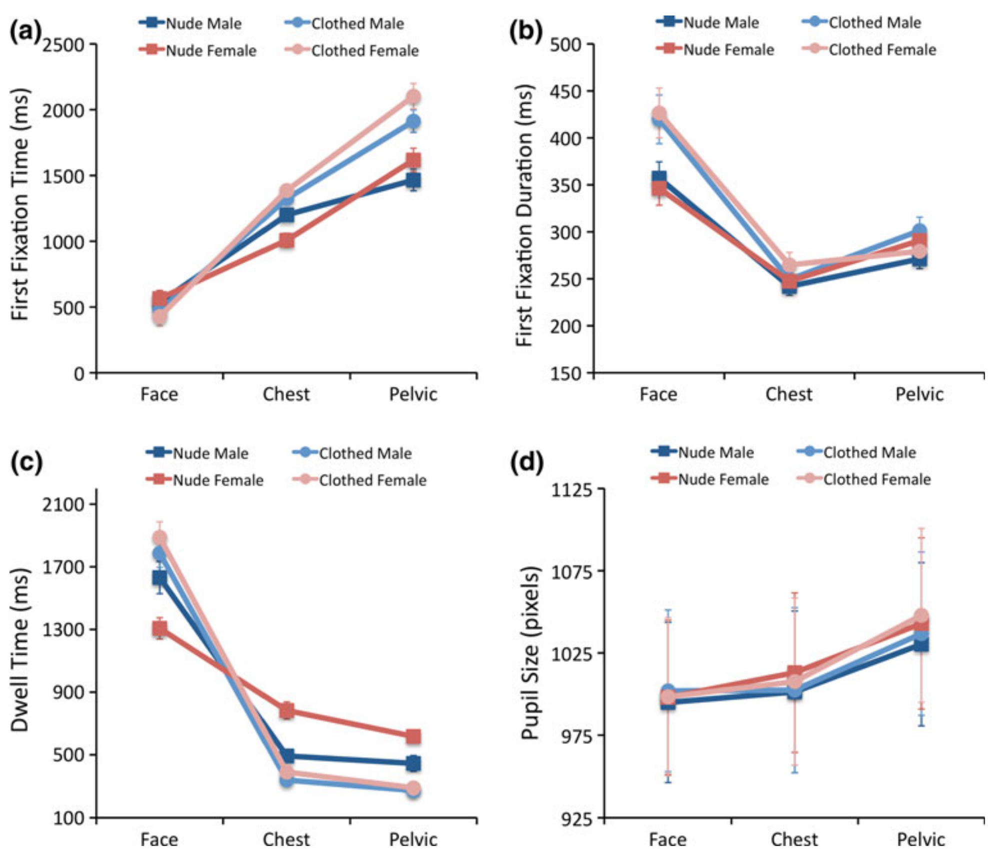

Fig. 3 Means and standard errors of the ROI-based measures of first fixation times (**a**), first fixation duration (**b**), dwell time (**c**), and pupil size (**d**) in Experiment 1

ROI-Based Eye Movement Measures

The ROI data were analyzed with a 2 (gender) × 2 (clothing) × 3 (ROI) ANOVA, and the results are summarized in Fig. 3 and in Table 2. For *first fixation time*, there were main effects of clothing and ROI. ROIs were looked at earlier when the stimuli were nude than clothed ($M_{\text{nude}} = 1{,}064$ ms, $M_{\text{clothed}} = 1{,}270$ ms), and faces were looked at earlier than chest, $F(1, 29) = 126.89$,

Table 2 Summary of the results of the ANOVAs for the ROI data in Experiment 1

Source	df	F	η_p^2	p
First fixation time				
Gender	1,29	1.77	.06	ns
Clothing	1,29	65.62	.69	<.01
ROI	2,58	154.08	.84	<.01
Gender × Clothing	1,29	4.44	.13	.04
Gender × ROI	2,58	4.45	.13	.02
Clothing × ROI	2,58	27.64	.49	<.01
Gender × Clothing × ROI	2,58	4.01	.12	.02
First fixation duration				
Gender	1,29	<1	.01	ns
Clothing	1,29	16.77	.37	<.01
ROI	2,58	49.15	.63	<.01
Gender × Clothing	1,29	<1	.01	ns
Gender × ROI	2,58	<1	.02	ns
Clothing × ROI	2,58	7.11	.20	<.01
Gender × Clothing × ROI	2,58	3.74	.11	.03
Dwell time				
Gender	1,29	8.23	.22	<.01
Clothing	1,29	6.12	.17	.02
ROI	2,58	166.70	.85	.01
Gender × Clothing	1,29	<1	.01	ns
Gender × ROI	2,58	17.31	.37	<.01
Clothing × ROI	2,58	38.32	.57	<.01
Gender × Clothing × ROI	2,58	24.47	.46	<.01
Pupil size				
Gender	1,29	1.98	.06	ns
Clothing	1,29	<1	.01	ns
ROI	2,58	57.02	.66	.01
Gender × Clothing	1,29	<1	.01	ns
Gender × ROI	2,58	1.00	.03	ns
Clothing × ROI	2,58	<1	.03	ns
Gender × Clothing × ROI	2,58	<1	.01	ns

$p < .001$, $\eta_p^2 = .81$, or pelvic region, $F(1, 29) = 233.59$, $p < .001$, $\eta_p^2 = .89$, and chest was looked at earlier than pelvic region, $F(1, 29) = 62.19$, $p < .001$, $\eta_p^2 = .68$. Mean first fixation times were $M_{face} = 499$ ms, $M_{chest} = 1{,}229$ ms and $M_{pelvic} = 1{,}774$ ms.

There were also interactions of gender and clothing, gender and ROI, clothing and ROI, as well as gender × clothing × ROI. The gender × clothing interaction reflects the fact that the latency of first fixation was similar for nude male and female stimuli, $F < 1$, whereas it was faster for clothed males versus females, $F(1, 29) = 4.20$, $p < .05$, $\eta_p^2 = .13$. For the interaction of gender × ROI, none of the planned comparisons reached significance after correcting for multiple comparisons. The clothing by ROI interaction resulted from participants fixating chest, $F(1, 29) = 21.64$, $p < .001$, $\eta_p^2 = .43$, and pelvic region, $F(1, 29) = 9.88$, $p < .01$, $\eta_p^2 = .25$, earlier for nude than clothed figures, whereas faces were looked at earlier when the stimuli were clothed than nude, $F(1, 29) = 55.33$, $p < .001$, $\eta_p^2 = .66$. The three-way-interaction reflects the fact that numerically the above effect was larger for male than female stimuli, but planned comparisons did not reach significance.

For *first fixation duration*, there were main effects of clothing and ROI. First fixations were longer for clothed than for nude bodies ($M_{nude} = 292$ ms, $M_{clothed} = 323$ ms), and for faces than for chest, $F(1, 29) = 59.50$, $p < .001$, $\eta_p^2 = .67$, or pelvic region $F(1, 29) = 40.67$, $p < .001$, $\eta_p^2 = .58$, ($M_{face} = 387$ ms, $M_{chest} = 250$ ms, $M_{pelvic} = 285$). There were also interactions of clothing × ROI, and gender × clothing × ROI. First fixations on faces were longer when bodies were clothed rather than nude, $F(1, 29) = 14.76$, $p < .001$, $\eta_p^2 = .34$, whereas clothing did not influence first fixation durations for chest or pelvic region, Fs < 1. The three-way interaction resulted from the fact that faces of clothed versus nude females, $F(1, 29) = 16.30$, $p < .001$, $\eta_p^2 = .36$, received longer first fixations, whereas the effect was only marginally significant ($p = .09$) for males.

For *dwell times*, the data generally replicated those obtained with the heatmap analyses. The ANOVA revealed main effects of gender, clothing, and ROI, showing that participants inspected female pictures longer than male pictures ($M_{female} = 878$ ms, $M_{male} = 827$ ms), and nude pictures longer than clothed pictures ($M_{nude} = 879$ ms, $M_{clothed} = 827$ ms). Furthermore, faces were inspected longest, followed by chest and pelvic ROIs ($M_{face} = 1{,}653$ ms, $M_{chest} = 500$ ms, $M_{pelvic} = 405$ ms). There were also interaction effects of gender × ROI, clothing × ROI, as well as gender × clothing × ROI. Simple effects tests revealed that participants looked longer at the female versus male chests, $F(1, 29) = 37.10$, $p < .001$, $\eta_p^2 = .56$, and pelvic regions, $F(1, 29) = 11.31$, $p < .01$, $\eta_p^2 = .28$, whereas they fixated longer on male than female faces, $F(1, 29) = 6.70$, $p < .05$, $\eta_p^2 = .19$. The clothing by ROI interaction reflects the fact that the chest, $F(1, 29) = 65.78$, $p < .001$, $\eta_p^2 = .69$, and pelvic regions, $F(1, 29) = 61.84$, $p < .001$, $\eta_p^2 = .68$, were inspected longer when the bodies were nude, whereas faces were inspected longer when the bodies were clothed, $F(1, 29) = 22.27$, $p < .001$, $\eta_p^2 = .68$. The three-way interaction is due to the effect of clothing on viewing times being different for male than female stimuli. For both genders, chest and genitals were observed longer when the stimuli were nude, but nudity decreased looking at female faces without influencing looking times for male faces, Fs > 5.28, ps $< .05$, η_p^2s $> .15$.

For *pupil size,* there was only a main effect of ROI, with fixations on the pelvic region resulting in larger pupil sizes than fixations on faces, $F(1, 29) = 68.03$, $p < .001$, $\eta_p^2 = .70$, or chests, $F(1, 29) = 72.00$, $p < .001$, $\eta_p^2 = .71$.

Discussion

Experiment 1 confirmed that visibility of sexual cues and the gender of the person being observed have a strong impact on how the information conveyed by bodies and faces was sampled

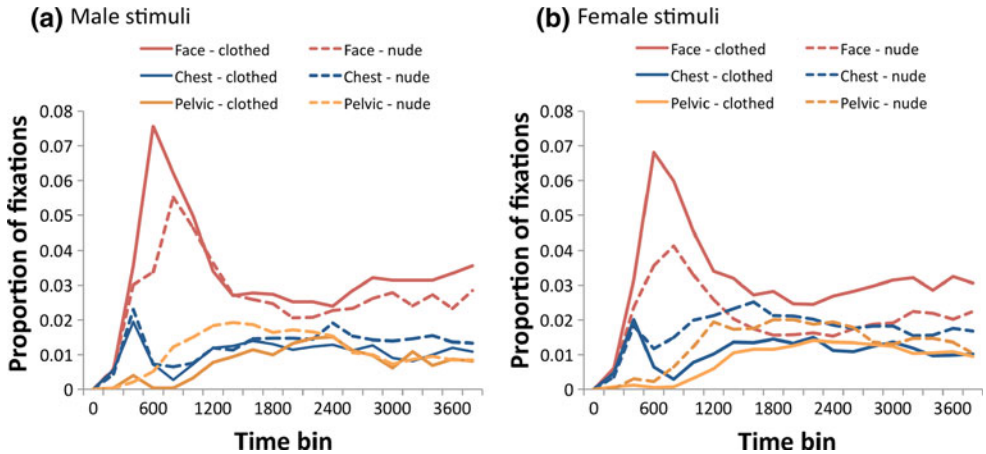

Fig. 4 Time course of allocating attention to the face, chest and pelvic regions of clothed and nude male (**a**) and female (**b**) stimuli in Experiment 1. *Y*-axis shows the proportion of fixations in each 200-ms time bin

by males. First, the data showed that visual scanning of humans begins from the face, regardless of whether or not the primary and secondary sexual cues were covered by clothing. The first fixations landed on the faces, with an average latency of 500 ms. Faces also received longest first fixations and were looked at for the longest duration. This is compatible with the profound role of faces in social signaling (Calder & Young, 2005), as well as with studies showing that faces capture attention reflexively (Langton, Law, Burton, & Schweinberger, 2008; Theeuwes & Van der Stigchel, 2006). We qualify these data by showing that, even for full-body figures showing a number of cues relevant for social and sexual perception, the visual information conveyed by the face was almost always addressed first (see also Janelle, Hausenblas, Ellis, Coombes, & Duley, 2009). Although bodily features provide reliable cues for women's reproductive fitness (Pouliot et al., 1994; Singh, 1993), our data suggest that men put the initial evaluative emphasis on the face, probably because it conveys information regarding *both* health and fitness as well as individual's motivational and emotional states that may influence the likelihood of successful social interaction and potential mating (Rhodes, 2006).

The fixations on the face were followed by a gradual downward shift in fixations towards chest and then finally to pelvic regions (see Fig. 4). Both fixation heatmaps and ROI-based analyses revealed that the visual scanning of the face, chest, and pelvic regions were influenced by both stimulus gender and clothing. Participants made more fixations on opposite than same-gender stimuli, and the spatial distribution of fixations was asymmetrical for male and female stimuli. Participants looked longer at male rather than female faces, whereas they looked longer at female versus male chest and pelvic regions. The bias towards female chest and pelvic regions probably reflects the fact that these regions signal reproductive fitness (Jasienska, Ziomkiewicz, Ellison, Lipson, & Thune, 2004; Pouliot et al., 1994; Singh, 1993), and evaluating these features of opposite-gender humans (i.e., potential mating partners) would thus be an automatic, biological predisposition. However, such evaluations would not be necessary for males. Instead, facial information related, for example, to social dominance or aggressiveness would be more important to acquire.

When sexual characteristics were visible, the stimuli were inspected more thoroughly. Importantly, our data revealed that the aforementioned primacy in scanning the face was overshadowed by the stimulus gender and the visibility of sexual characteristics. When the bodies were shown without clothes, first fixations on faces occurred later and were much shorter. On the contrary, first fixations on both chest and pelvic regions were longer and occurred much earlier on the nude stimuli. Moreover, the total time spent observing these sexually relevant regions was significantly longer when the stimuli were shown nude rather than with clothing. This suggests that clothing indeed covers important information related to sexual processing that male observers nevertheless strive to acquire. The inspection of the chest and pelvic regions was also associated with elevated physiological arousal as evidenced by pupillometric responses, confirming that viewing these regions was probably related to sexual interest. Importantly, all these effects were observed in a free viewing condition rather than under specific instructions; thus, they reflect the observers' natural, biological predisposition to scanning the bodily image. Finally, it must be stressed that although both nude and clothed opposite-sex stimuli were considered pleasant, only nude stimuli were rated highly arousing. Accordingly, it is likely that the arousal level rather than the activation of the approach motivation system is associated with the enhanced scanning of the sexual features of the opposite-sex nudes.

Although Experiment 1 convincingly demonstrated that male human observers inspect nude bodies more thoroughly than clothed bodies and that they are biased towards viewing the opposite-gender bodily regions that are relevant for identifying potential sexual partners, it could be argued that there simply is more significant information in this region of female rather than male bodies (especially WHR). Hence, the scan pat-

Table 3 Summary of the results of the ANOVAs for the ROI data in Experiment 2

Source	df	F	η_p^2	p
Dwell time				
Participant gender	1,36	<1	.01	ns
Gender	1,36	8.13	.18	<.01
Gender × Participant gender	1,36	7.76	.18	<.01
Clothing	1,36	32.33	.47	<.01
Clothing × Participant gender	1,36	<1	.00	ns
ROI	2,72	115.76	.76	<.01
ROI × Participant gender	2,72	2.24	.06	ns
Gender × Clothing	1,36	17.26	.32	<.01
Gender × Clothing × Participant gender	1,36	2.49	.07	ns
Gender × ROI	2,72	13.41	.27	.01
Gender × ROI × Participant gender	2,72	<1	.01	ns
Clothing × ROI	2,72	45.24	.56	<.01
Clothing × ROI × Participant gender	2,72	1.55	.04	ns
Gender × Clothing × ROI	2,72	13.21	.27	<.01
Gender × Clothing × ROI × Participant gender	2,72	10.71	.23	<.01
Pupil size				
Participant gender	1,36	<1	.02	ns
Gender	1,36	<1	.00	ns
Gender × Participant gender	1,36	8.02	.18	<.01
Clothing	1,36	1.93	.05	ns
Clothing × Participant gender	1,36	1.32	.04	ns
ROI	2,72	41.16	.53	<.01
ROI × Participant gender	2,72	<1	.02	ns
Gender × Clothing	1,36	2.36	.06	ns
Gender × Clothing × Participant gender	1,36	1.82	.05	ns
Gender × ROI	2,72	3.75	.09	.03
Gender × ROI × Participant gender	2,72	<1	.03	ns
Clothing × ROI	2,72	<1	.00	ns
Clothing × ROI × Participant gender	2,72	<1	.01	ns
Gender × Clothing × ROI	2,72	<1	.00	ns
Gender × Clothing × ROI × Participant gender	2,72	<1	.02	ns

terns may simply reflect the amount of information conveyed by the male and female stimuli, rather than sexual interest. Additionally, it is possible that the gaze patterns observed in Experiment 1 might not generalize to woman observers. It has actually been established that men prefer physically attractive partners more than women (Buss & Barnes, 1986), which suggests that men and women could indeed view same and opposite gender bodies differently. To generalize our results to both sexes, we conducted Experiment 2 in which we evaluated the gaze patterns of men and women who viewed pictures of nude and clothed male and female stimuli. If biases towards viewing chest and pelvic regions truly reflect viewing strategies specific for sexual interest, we expected to observe an interaction of stimulus gender, observer gender and region of interest for the dwell times.

Experiment 2

Method

Participants and Procedure

Experiment 2 essentially replicated Experiment 1 with the exception that eye movements of both men and women were studied. Thirty-eight undergraduate students (22 women, 16 men) participated for course credit. All were heterosexual on the basis of the Sell Assessment of Sexual Orientation scores (Sell, 1996). ROI-based data analyses were conducted similarly to Experiment 1 with the exception that participant gender was introduced as a between-subjects factor in the ANOVA.

Results

Global Eye Movement Measures

Saccade latencies were not influenced by any experimental factor, Fs < 1.5. For *fixation count*, there was a main effect of stimulus gender, $F(1, 36) = 7.43$, $p < .01$, $\eta_p^2 = .17$, and clothing, $F(1, 36) = 37.21$, $p < .001$, $\eta_p^2 = .51$. In general, more fixations

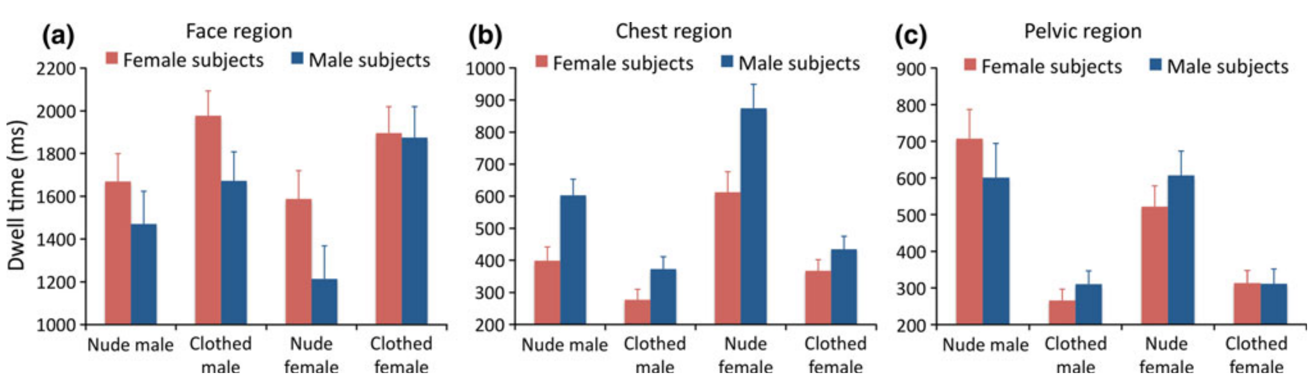

Fig. 5 Means and SD of the dwell times for face (**a**), chest (**b**), and pelvic (**c**) region, as a function of stimulus and participant gender in Experiment 2

were made on female than male stimuli ($M_{\text{female}} = 10.44$, $M_{\text{male}} = 10.20$) and on nude than clothed stimuli ($M_{\text{nude}} = 10.84$, $M_{\text{clothed}} = 9.80$). These main effects were qualified by an interaction of stimulus gender × clothing × participant gender, $F(1, 36) = 6.31$, $p < .05$, $\eta_p^2 = .15$. Simple effects tests revealed that men made more fixations on nude than clothed stimuli, $F(1, 15) = 50.52$, $p < .001$, $\eta_p^2 = .77$, whereas for women the difference between nude and clothed stimuli was larger for female than for male stimuli, $F(1, 21) = 10.74$, $p < .01$, $\eta_p^2 = .34$.

ROI-Based Eye Movement Measures: Interactions with Participant Gender

The overall pattern of first fixation time, first fixation duration and dwell time essentially replicated that observed in Experiment 1. Only the analysis of dwell times resulted in interactions involving subject gender; thus, the other main effects and interactions not involving subject gender are not presented here for the sake of conciseness (see Table 3 for the full ANOVA results for these measures). For *dwell time*, there were interactions of participant gender × stimulus gender, and participant gender × stimulus gender × clothing × ROI. The two-way interaction reflects the fact that women observed the male and female stimuli equally long, whereas men showed a clear preference towards female stimuli, $F(1, 15) = 10.54$, $p < .01$, $\eta_p^2 = .41$. The four-way interaction was decomposed by analyzing data from each ROI separately with 2 (participant gender) × 2 (stimulus gender) × 2 (clothing) mixed ANOVAs and corresponding simple effects tests (Fig. 5).

For *face region*, there was a three-way interaction of participant gender, stimulus gender and clothing, $F(1, 36) = 16.67$, $p < .001$, $\eta_p^2 = .32$. Simple effects tests showed that women looked longer at male than female faces, $F(1, 21) = 7.75$, $p < .05$, $\eta_p^2 = .18$, and at faces of clothed bodies than faces of nude bodies, $F(1, 21) = 9.76$, $p < .01$, $\eta_p^2 = .32$ whereas men looked more at faces of nude male than nude female figures, $F(1, 15) = 11.44$, $p < .01$, $\eta_p^2 = .43$, and more at faces of clothed female than nude female figures, $F(1, 15) = 9.02$, $p < .01$, $\eta_p^2 = .38$.

For *chest region*, there was a main effect of participant gender, $F(1, 36) = 8.94$, $p < .01$, $\eta_p^2 = .20$, showing that men spent overall more time looking at the chest region than did women. Furthermore, the bias towards nude versus clothed chests was larger in magnitude among men than women, as evidenced by a clothing × participant gender interaction, $F(1, 36) = 5.93$, $p < .05$, $\eta_p^2 = .14$.

For *pelvic region*, there was a three-way interaction of participant gender × stimulus gender × clothing, $F(1, 36) = 7.38$, $p < .01$, $\eta_p^2 = .17$. This interaction resulted from the fact that men looked equally long at nude male and female pelvic region, as well as clothed male and female pelvic region, whereas women looked more at nude male versus female pelvic region, $F(1, 21) = 17.51$, $p < .001$, $\eta_p^2 = .46$, with no significant differences in looking times for clothed female and male pelvic regions. Additionally, men looked longer at nude female pelvic regions than women, $F(1, 37) = 5.23$, $p < .05$, $\eta_p^2 = .12$.

For *pupil size*, there was a main effect of ROI, $F(2, 72) = 41.59$, $p < .001$, $\eta_p^2 = .53$, as well as an interaction of stimulus gender and ROI, $F(2, 72) = 3.75$, $p < .05$, $\eta_p^2 = .10$. Pupil size was larger when participants were inspecting pelvic rather than chest, $F(1, 36) = 43.73$, $p < .001$, $\eta_p^2 = .55$, or face, $F(1, 36) = 45.83$, $p < .001$, $\eta_p^2 = .56$, region, and larger when they were looking at chest rather than face region, $F(2, 72) = 25.66$, $p < .001$, $\eta_p^2 = .42$. None of the planned comparisons for the two-way interaction reached significance. There was also an interaction of participant gender and stimulus gender, $F(1, 36) = 8.02$, $p < .01$, $\eta_p^2 = .18$. Women showed a greater pupillary response towards male than female stimuli, $F(1, 21) = 5.38$, $p < .05$, $\eta_p^2 = .20$, whereas the opposite was true for men although the effect was only marginally significant, $F(1, 15) = 3.01$, $p = .10$, $\eta_p^2 = .17$.

Discussion

Experiment 2 confirmed that women showed a similar spatio-temporal pattern of fixations on bodies as seen with male observers in Experiment 1. Moreover, clothing had a strong effect on both men's and women's gaze patterns. For both men and women, nude versus clothed stimuli received more fixations, and removal of the clothing biased fixations away from the face towards the chest and pelvic regions. This confirms that, for both genders, nudity is an important attentional cue, which leads to more detailed inspection of the human body.

However, participant and stimulus gender as well as stimulus clothing influenced interactively the viewing patterns: Whereas men showed a clear preference for viewing the opposite-gender stimuli, women did not show a preference towards either gender. Only when fixations on the face region were considered, more fixations on opposite-gender faces were found for women. These data accord with findings showing that men pay more attention to visual qualities in mate choice than females (Buss & Barnes, 1986), and are also compatible with the prevailing view of sexual responsiveness, suggesting a greater discrimination of physiological responses to sexually arousing opposite-gender versus same-sex stimuli among men than women (Alexander & Charles, 2009; Costa et al., 2003; Costell, Lunde, Kopell, & Wittner, 1972; Hietanen & Nummenmaa, 2011; Lykins, Meana, & Strauss, 2008; Quinsey, Ketsetzis, Earls, & Karamanoukian, 1996). On the other hand, our pupillometric measures suggest that viewing opposite versus same-sex stimuli elicit larger arousal responses in both genders, indicative of arousal contingent on sexual interest while viewing the bodies. This extends prior studies showing an elevated pupillary response to auditorily presented, sexually arousing versus non-arousing cues (Dabbs, 1997) by demonstrating that similar effects are also observed in the visual domain.

Both men and women looked longer at female versus male chests, even with clothed stimuli. Furthermore, men spent more time looking at the chest region than women, and clearly preferred the chests of nude females to nude males. This is in line with the findings showing that, in women, mere breast size is a reliable marker of reproductive fitness (Jasienska et al., 2004) and thus probably attracts more attention from male viewers. Consistent with this, it has been found that judging attractiveness from headless semi-nude stimuli biases eye movements towards the chest region (Cornelissen, Hancock, Kiviniemi, George, & Tovee, 2009). On the other hand, women showed a clear preference for opposite versus same-gender pelvic region in the nude figures, whereas a similar bias (i.e., enhanced attention to nude female vs. male pelvic region) was not found for men. It has been proposed that the human penis size has evolved particularly due to female sexual selection (Miller, 1998), and in line with this, a considerable number of women value the size of partner's penis (Francken, van de Wiel, van Driel, & Weijmar Schultz, 2002; Stulhofer, 2006), which may explain women's selective scanning of the pelvic-genital regions of the nude males.

General Discussion

In two eye movement experiments, we investigated how the visibility of sexual cues of male and female bodies influenced visual processing of the bodily image by men and women. The experiments yielded three important conclusions. First, we were able to characterize a spatiotemporal, top-to-bottom viewing pattern that human observers follow when inspecting conspecifics' bodies. Second, we demonstrated how the clothing of the bodies modulated this overall pattern of fixations, with visible sexual characteristics leading to more detailed overall inspection of the image and to a particular focus on the features relevant to identifying potential sexual partners and their mate value. Third, we demonstrated that participants' gender (and, simultaneously, their sexual interest, as we only included heterosexual participants) had a large impact on how nude bodies were inspected.>

How do Humans View Bodies and Faces?

The first fixation typically landed on the face; moreover, faces were inspected for the longest duration, although participants also spent considerable time viewing the lower chest and pelvic regions of the body. As the face conveys information regarding both typical and situational behavior (Calder & Young, 2005; Haxby et al., 2000), the initial processing of the facial information (such as gender, facial expression, and so forth) supports subsequent interpretation of information acquired from the bodily image. Although attention capture by faces against objects and animals is a robust phenomenon (Langton et al., 2008; Theeuwes & Van der Stigchel, 2006), prior studies have provided contradictory evidence regarding the primacy of examining the face versus other body regions when viewing full-body images (Dixson et al., 2009; Hewig et al., 2008). Our high-resolution eye tracking data confirmed that even when the chest and genital regions of figures were made sexually salient by removal of the clothes, the face was still fixated first. All the other previous studies have shown the stimuli at fixation; thus, even the very first fixation was forced to land on a predefined region of the body, which obviously confounds with the obtained results. In contrast, we presented stimuli outside of the participants' initial foveal field of view and jittered the vertical stimulus position to ensure that stereotypical viewing strategies, such as making always a horizontal saccade upon stimulus presentation, cannot contaminate the results. Taken together, these data suggest that the face is indeed the most relevant signal for human interactions, and human observers strive to grasp the information conveyed by the face first.

Enhanced Attention to Nude Bodies

As predicted, scanning of all three ROIs (face, chest, and pelvic regions) was contingent on the visibility of sexual cues. Most importantly, nude stimuli received more fixations than clothed ones. Increased number of fixations on scene regions and objects is indicative of how much diagnostic information they contain and how much observers prefer them (Henderson, 2003; Shimojo, Simion, Shimojo, & Scheier, 2003). Thus, the automatic tendency to pay more attention to nude bodies indicates that the visual system is biased to process this type of biologically salient information. Although faces were, in general, inspected first and longest, this tendency was dramatically reduced when the bodies were presented without clothing. Viewing nude bodies was associated with earlier fixations on the chest and pelvic regions, and enhanced attention paid (as indexed by dwell time) to these bodily regions.

Prior evidence from eye movement studies suggests that the chest and pelvic regions are important for the assessment of features relevant to sexual selection. When judging gender from point-light walker stimuli, participants focus on the hip region of the figures, although a substantial number of fixations also land on the shoulder region (Saunders, Williamson, & Troje, 2010). Rating WHR from headless, semi-nude bodies biases fixations towards the pelvic region, whereas rating attractiveness biases fixations towards the chest region (Cornelissen et al., 2009). Our study did not involve an explicit judgment task so we cannot disentangle from the obtained results the relative contribution of attractiveness and reproductive fitness. However, it is plausible to assume that both features play a role in guiding eye movements to the chest and pelvic regions in the nude bodies.

The finding that looking at chest and pelvic regions was associated with elevated physiological arousal and that the latencies of the first fixations to these regions were shorter when the bodies were shown without clothes accords with prior eye movement studies demonstrating an automatic bias in directing gaze towards pleasant, highly arousing visual content (Calvo & Lang, 2004; Nummenmaa, Hyönä, & Calvo, 2006, 2009). However, on the basis of the present data, we cannot conclude whether or not the nude chest and genital regions would have captured visual attention automatically. Nevertheless, as prior studies have demonstrated automatic attention capture by sexual cues (Jiang et al., 2006; Most et al., 2007), it seems plausible to assume that the bias towards nude chests and pelvic regions observed in the present study would reflect automatic engagement of the visual attention circuits upon perception of sexual cues.

Men and Women View Bodies Differently

Pupillometric analyses confirmed that the stimuli triggered an arousal response contingent on sexual interest: opposite-gender stimuli were associated with elevated arousal in both heterosexual men and women. The gaze patterns while viewing bodily images were also strongly contingent on both the observer and stimulus gender. Men made more fixations on the opposite rather than same-gender stimuli, which accords with the data showing that men value partners' physical qualities in mate choice more than women (Buss & Barnes, 1986). Specifically, men prefer the female chest and pelvic regions at the expense of the face, whereas an opposite pattern emerged when they viewed male stimuli (cf. Fig. 2). Men also preferred viewing the nude versus clothed chests more than women. As the female chest and pelvic regions are indicative of both attractiveness and physical and reproductive fitness (Jasienska et al., 2004; Pouliot et al., 1994; Singh, 1993), fixations on these regions probably reflect an automatic tendency to evaluate these features.

Women also showed selective and strong biases towards specific features of opposite-gender figures, but, unlike men, they paid more attention to the opposite- versus same-gender faces. Although bodily cues, such as muscularity, are also important for women's appraisals of men's attractiveness (Frederick & Haselton, 2007), certain facial characteristics might be even more important for mate valuation. The sexual strategies theory (Buss & Schmitt, 1993) posits that, in human sexual selection, men emphasize more youth and good looks, whereas women are more attentive to cues signaling characteristics related to ambition and status. Findings demonstrating that facial characteristics, such as eye gaze and maturity, rather than specific bodily features, provide cues that signal social status in humans (Allison, Puce, & McCarthy, 2000; Rule & Ambady, 2008; Todorov, Said, Engell, & Oosterhof, 2008) may explain women's bias towards viewing male faces. On the other hand, although faces are a reliable cue for age, bodily features, such as form and breast development, are more important markers of age and sexual development of females, which would explain the men's bias towards viewing the chest regions in female stimuli.

Limitations and Future Directions

One obvious limitation of the study was that our stimulus figures were not fully standardized across categories. Even though we were careful to match stimulus categories with respect to gaze contact and facial expression, the postures varied slightly across models. Although such variability increases the ecological validity of the study by introducing natural variability and unpredictability to the stimuli, it is possible that it may have affected the eye movement patterns. Furthermore, we did not parametrically vary the amount of clothing the stimulus persons were wearing. We have recently established that body-sensitive event-related potentials measured from the occipitotemporal cortex are parametrically modulated by the degree of clothing (nude–swimsuits–full clothing) worn by the stimulus persons (Hietanen & Nummenmaa, 2011); thus, it would be interesting to use a similar approach in eye movement studies. Also, studies on subpopulations with low sexual desire, such as children or neurological patient groups with hypo- and hypersexuality, would provide important insight regarding the role of sexual drive in guiding attentional deployment during perception of nude and clothed bodies.

It is also possible that the nude stimuli could simply have been more novel and hence captured attention more readily. However, this explanation seems unlikely, given that all the stimuli were photos of unfamiliar models (e.g., pictures of famous actors were not used) acquired from Internet sites. Thus, there is no reason to expect that the participants would have been more familiar with any of the clothed figures. Alternatively, it could be argued that we see nude stimuli more infrequently; hence, they would be more novel and more attention-grabbing. However, it must be noted that the gaze patterns to nude versus clothed figures were contingent on the observer's gender; hence, it is unlikely that mere novelty of nude bodies could explain the differential gaze patterns to nude versus clothed figures. Finally, it must be stressed that we employed static photograph stimuli, which fail to capture the intrinsic dynamic nature of human bodies. Given that eye movements can be easily recorded and analyzed during dynamic body perception as well (see, e.g., Nummenmaa, Hyönä, & Hietanen, 2009), future studies need to explore gender differences in more naturalistic tasks involving dynamic clothed and nude persons.

Conclusions

Presence of sexual cues biases the human visual system in extracting information from the human bodily image. Nude bodies attract more attention, particularly to the regions relevant for the identification of sexual partners. We propose that the augmented and gender-contingent visual scanning of nude bodies reflects selective engagement of the visual attention circuits upon perception signals relevant to mate value, which supports mating and reproduction. When this sexually relevant information is not available, fixations shift towards the face, which also conveys socially and sexually relevant information, but is rarely covered by clothing. It is thus intriguing to ask whether the often reported strong biases towards viewing human faces could at least partially reflect the (learned) fact that faces are usually the most reliably available source of information relevant in forming sexual and interpersonal relationships in societies where clothes are worn regularly.

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