TURUN YLIOPISTO

Sex differences in gaze patterns while viewing sexual stimuli:

An eye-tracking study

Master's thesis

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Abstract

Mate choice preferences have been extensively studied and it is known that faces and bodies serve as important cues of physical attractiveness and reproductive fitness. Previous research of sexual perception suggests that there are sex-related differences in the visual processing of erotic stimuli. In this study, we collected eye movement data from 43 male and 67 female participants to investigate gaze patterns and sex differences during perception of dynamic (Experiment 1) and static (Experiment 2) erotic stimuli. Dwell times were longest for faces in both experiments and faces were almost always the first thing to catch attention. We also discovered clear sex differences for both stimulus types. In the video experiment, male participants looked more at female chest, buttocks, and genital areas while female participants looked more at male faces. Clothing of the stimulus had also a strong impact on the gaze patterns in the picture experiment: gaze was directed mainly on faces when the stimuli were clothed, while nude stimuli received more fixations on genital and chest areas. Our results accord with previous studies. The differences between experiments suggest that dynamic, more real-life representative, erotic stimuli are processed differently in the visual system than pictures.

Keywords: Sexual perception – Eye-tracking – Visual attention – Gender differences - Pupil size

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Tiivistelmä

Parinvalintaan liittyviä mieltymyksiä on tutkittu laajasti ja tiedetään, että kasvot ja kehot antavat tärkeää tietoa ulkoisesta viehättävyydestä ja lisääntymiskyvystä. Aiemmat tutkimukset ovat osoittaneet sukupuolten välisiä eroja eroottisen materiaalin visuaalisessa prosessoinnissa. Tähän silmänliiketutkimukseen osallistui yhteensä 43 miestä ja 67 naista, jotka havainnoivat sekä dynaamisia (Koe 1) että staattisia (Koe 2) eroottisia ärsykkeitä. Kerätystä aineistosta tutkimme silmänliikkeitä ja niissä esiintyviä sukupuolten välisiä eroja. Analyyseissä selvisi että koeasetelmasta riippumatta kokonaiskatseluajat olivat pisimpiä kasvoihin, ja katse kiinnittyi lähes poikkeuksetta ensimmäisenä kasvojen alueelle. Lisäksi selvät sukupuolten väliset erot tulivat ilmi molemmissa kokeissa. Videoissa miehet katsoivat enemmän naisten rintoja, pakaroita ja genitaalialuetta, samalla kun naiset katsoivat enemmän miesten kasvoja. Myös vaatetuksella oli vahva vaikutus silmänliikkeisiin kuvien katselussa: katse kohdistui lähes pelkästään kasvoihin kun katsottiin vaatetettuja henkilöitä, kun taas alastomien henkilöiden genitaalialueet ja rinnat keräsivät myös katseita. Tuloksemme ovat yhteneväisiä aikaisempien tutkimusten kanssa. Erot kokeiden välillä antavat viitteitä siitä, että dynaamiset ja todenmukaisemmat eroottiset ärsykkeet prosessoidaan visuaalisesti staattisista kuvista poikkeavasti.

Avainsanat: Seksuaalinen havainnointi – Silmänliiketutkimus – Visuaalinen tarkkaavaisuus – Sukupuolten väliset erot – Pupillikoko

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Introduction

Mate selection and sexuality are essential parts of human life. Mate preferences have been extensively studied and it is known that faces and bodies are important cues of physical attractiveness and overall health (Frith, 2009; Jonason et al., 2012; Perilloux et al., 2010; Rhodes, 2006). Facial and bodily signals such as waist-hip-ratio and facial symmetry signal physical attractiveness of a potential partner. But humans also extract nonverbal cues from faces and bodies and this is essential for success in emotional communication and in interpersonal relationships (Bull, 2001). Such cues arise from body language and especially from facial expressions, which are critical for social engagement (Ishii et al., 2018). Such nonverbal communication is also critical for mating, in that communication skills has been linked to sexual satisfaction (Purnine & Carey, 1997), and the ability to read both verbal and non-verbal cues is important for enjoyable sexual intercourse. Eye-tracking methodology has been used increasingly to study sexual behaviours, particularly sexual perception and attention to sexual signals.

Eye-tracking indexes locus of attention through fixation distribution (Borys & Plechawska-Wójcik, 2017) and arousal via pupil dilation (Bradley et al., 2008). Studies using eye-tracking methodology have investigated, for example, differences in sexual arousal and desire between sexes (Farisello, 2017), visual attention to sexual stimuli in different levels of sexual functioning (Velten et al., 2021) and in special groups such as sexual offenders (Godet & Niveau, 2021). Studies using this methodology have shown that pupil dilation and pupil dilation patterns are significant indicators of sexual orientation and arousal (Rieger & Savin-Williams, 2012). Most reported eye-tracking measurement is a fixation. It is a state where eye remains still for a short period of time, anywhere between tens of milliseconds up to seconds. Other essential measurements are first fixation duration, how long was the first fixation on the stimulus, and dwell time, which reflects the overall time spent on the stimulus (Holmqvist et al., 2011).

Eye-tracking has numerous advantages in sex research when compared to other widely used methods such as self-reports and physiological measurements (Lykins et al., 2006) as it overcomes problems such as recall problematics, self-presentation bias and validity issues. Eye-tracking is an objective and continuous way to measure cognitive and visual information processing, while individuals view visual stimuli (Lykins et al., 2006). Therefore, it has been recognized to be an extremely useful method in the field of sexual research.

Eye tracking and sexual perception

Eye-tracking studies have shown that attention is in general biased towards emotionally relevant, either unpleasant (e.g. someone suffering) or pleasant (e.g. someone smiling) stimuli (Nummenmaa et al., 2006). Similarly, sexual stimulus attracts preferential attention when it is presented simultaneously with non-sexual stimulus (Fromberger et al., 2012). Multiple studies have also shown that erotic and non-erotic material are processed in different ways (Fromberger et al., 2012; Lykins et al., 2006; Nummenmaa et al., 2012). For example, observers make longer fixations to erotic stimuli, and nude versus clothed bodies are examined more thoroughly. This is evidenced by a greater number of fixations and longer fixation total times in chest and pelvic regions (Nummenmaa et al., 2012). While nudity biases the fixations away from the face, multiple studies have confirmed that faces are still attended the most: first fixations land almost always on the faces, and it is the region which attracts most of the overall attention even for nude bodies (Lykins et al., 2006; Nummenmaa et al., 2012; Tsujimura et al., 2009). These findings suggest that faces might be the most important source of sexual signals and supports the importance of faces in social engagement.

Gender differences in sexual behaviour and importance of dynamic stimuli

Females and males have different reproduction strategies, which reflect the different evolutionary selection pressures on human males and females (Buss, 1989). Females carry the metabolic cost of childbearing but are consequently a limited mating resource, and thus able to evaluate and choose potential partners to reproduce with, whereas males have theoretically unlimited reproductive potential but need to compete with each other to gain the access to mates (Workman & Reader, 2021). These differences in reproduction lead to different mating strategies, and possibly partially due to their larger reproductive capacity, males also have as well as stronger sexual drive than females (2001). This is also reflected in frequency and intensity of the desired amount of intercourse, desired number of partners and spontaneous thoughts about sex.

As the differences between sexes exist in sexual behaviour, the differences of processing sexual signals have also gained interest. Previous studies investigating sex differences in visual processing of sexual information have shown, in general, marked differences (Lykins et al., 2008; Rupp & Wallen, 2007). First, men and women allocate their attention differently. For example, Lykins et al. showed participants images of couples in sexual scenes and reported

that men viewed preferentially female sex figures, while women paid more equal attention to both sexes. This finding has been replicated in other studies (Fromberger et al., 2012; Nummenmaa et al., 2012; Tsujimura et al., 2009). Rupp and Wallen (2007) additionally discovered that men spent more time looking at female faces than women. Additionally, it has been reported that males tend to look more female chests and females look more male pelvic region (Nummenmaa et al., 2012). These differences in visual processing might reflect the attraction to the opposite sex and the evaluation of the physical properties of potential partner.

Human bodies are however always in motion, and the importance of body movements as part of a multichannel system of communication is well known (Bull, 2001). For example facial expressions, gazes, pupil sizes, postures and gestures give us valuable information about others intentions. In addition, the importance of body movements, e.g. dance performance, have been acknowledged to have a role in mate selection (Hugill et al., 2010). Yet, according to a systematic literature review (Wenzlaff et al., 2016), most studies on sexual perception have used static images of real or computer-generated human figures to study sexual attention. In turn, data from attention allocation during naturalistic, dynamic sexual scenes is extremely sparse. This is a critical gap in the literature, as there is prima facie doubt regarding the generalizability of the results of such simplistic studies to real-world dynamic human behaviour (Adolphs et al., 2016).

Video-based experiment could offer a valuable information since it has been suggested that videos evoke the highest levels of physiological and subjective arousal, and they are also more representative of real-life interaction and may produce more authentic patterns of visual attention (Julien & Over, 1988). Tsujimura and colleagues' (2009) preliminary study consisted of 22 male and female subjects who observed videos with sexual interaction. The results did not align with erotic stimulus studies using pictures: There were none statistically relevant sex differences in viewing patterns of the video. This indicates that studies using dynamic video stimuli are needed to understand how sexual perception occurs in naturalistic settings.

The Current Study

Previous studies investigating sexual perception have mainly used pictorial stimuli (Fromberger et al., 2012; Lykins et al., 2008; Rupp & Wallen, 2007), while the importance of dynamic video experiments has been recognized (Tsujimura et al., 2009). Therefore, the aim of this study was to investigate the visual processing of sexual stimuli while viewing dynamic,

more real-life representative stimuli, and compare the results to the static sexual stimuli experiment.

The main research questions were as follows:

1) Which areas of human body attract most attention in erotic stimuli?
2) Which regions in the stimuli catch the attention first?
3) Are there sex-related differences in gaze patterns on sexual stimuli?
4) How does the clothing of the stimulus affect to the gaze patterns?
5) Are there differences in the pupil size while viewing different regions of the stimuli?

Based on previous studies and the evolutionary perspective on sexual behaviour, our hypotheses were that sex-related differences in sexual perception would be discovered in both experiments, and that faces would attract preferential attention even in the sexual scenes. We assumed this to be reflected in earlier first fixations and the longer dwelling times on the face region. We also predicted that the clothing of the stimulus would affect the gaze patterns, such that nude bodies would be processed more thoroughly. This would be seen in diminished dwell times on faces and in more fixations to other areas. Additionally, we assumed that differences in pupil sizes would be discovered, as it is known that pupil dilation indicates arousal.

Materials and methods

Participants

A total of 110 subjects volunteered for the study. The mean age was 27 years and 43 of the participants were males (38.7%). Descriptive data of the participants is presented in Table 1. Subjects' recruitment was done via emails (University of Turku email lists), flyers on notice boards and via social media platforms (e.g. Facebook, Reddit). Before the experiment, all participants were informed with their rights and how the information will be used in the future and a written consent was collected. Participants were compensated with lunch and movie tickets.

Inclusion criteria of the participants were age > 18 years. Exclusion criteria were 1) diagnosis of reading impairment or neurological/ psychiatric disorder, 2) substance abuse and 3) current medication influencing nervous system.

Table 1 Mean scores (M) and standard deviations (SD) of the participants' background information (age, handedness, and education).

	Age **years**	**Handedness** **n (%)**	**Education*** **n (%)**
Female	M = 29.2 SD = 9.36	Right = 58 (0.87) Left = 6 (0.09) Both = 3 (0.04)	1 = 1 (0.01) 2 = 28 (0.42) 3 = 38 (0.57)
Male	M = 25.7 SD = 9.10	Right = 42 (0.98) Left = 1 (0.02)	1 = 2 (0.05) 2 =11 (0.26) 3 = 30 (0.70)

**Education levels: 1.= primary school, 2.= secondary school, 3.= higher education*

Participant's sexual attraction to males and females was measured with a scale ranging from 0 (not at all attracted) to 100 (highly attracted) as a part of background information form. The experienced and desired frequency of sexual acts was measured with a Likert scale ranging from 1 ("never") to 9 ("four or more times a day") as a part of Derogatis Sexual Functioning Inventory, DSFI (Derogatis, 1975). Both were self-report questionnaires. The measured sexual acts were the following: kissing and caressing, sexual fantasies, masturbation, oral sex, vaginal intercourse, and anal sex. Attraction measurements are presented in Table 2.

Table 2 Mean scores (M) and standard deviations (SD) of the participants' attraction measurements, and experienced and desired sexual acts.

	Attraction to women **(scale 0-100)***	**Attraction to men** **(scale 0-100)***	**Experienced sexual acts** **(scale 1-9)****	**Desired sexual acts** **(scale 1-9)****
Female	M = 33.7 SD = 27.9	M = 83.4 SD = 21.5	M = 3.12 SD = 1.09	M = 4.20 SD = 1.02
Male	M = 89.8 SD = 20.2	M = 16.3 SD = 25.6	M = 3.37 SD = 1.01	M = 4.65 SD = 1.28

** Attraction scale from 0 (=not attracted) to 100 (=highly attracted)*

*** Experiential and desired 1-9 Likert scale (1=never; 2= less than once a month; 3= once or twice a month; 4= once a week; 5= 2-3 times a week; 6= 4-6 times a week; 7= once a day; 8= 2-3 times a day; 9= 4 or more times /day)*

The study contained two parts: Eye-tracking and neuropsychological tests and questionnaires (e.g. N-BACK, TIPI, DSFI, DASS-21). Each subject participated in all tasks. In this study we concentrate on the two experiments related sexual perception: one with erotic videos and another with static images; the actual experimental batch also contained 16 unrelated tasks not reported here. Video experiment was the 5th and the picture experiment the 16th task of the study. Per the chairman of the local ethics committee, ethical self-evaluation was sufficient for the project and no formal evaluation by the ethics committee was required.

Eye tracking

We performed two eye movement experiments. Subjects viewed videos and pictures with sexual material (nudity, intercourse) while their eye movements were recorded using Eyelink 1000 eye-tracker (SR Research, Mississauga, Ontario, Canada; sampling rate 1000 Hz, spatial accuracy better than 0.5°, with a 0.01° resolution in the pupil-tracking mode). A nine-point calibration and validation were completed at least at the beginning of each task. Saccade detection was performed using a velocity threshold of 30°/ s and an acceleration threshold of 4000°/ s^2.

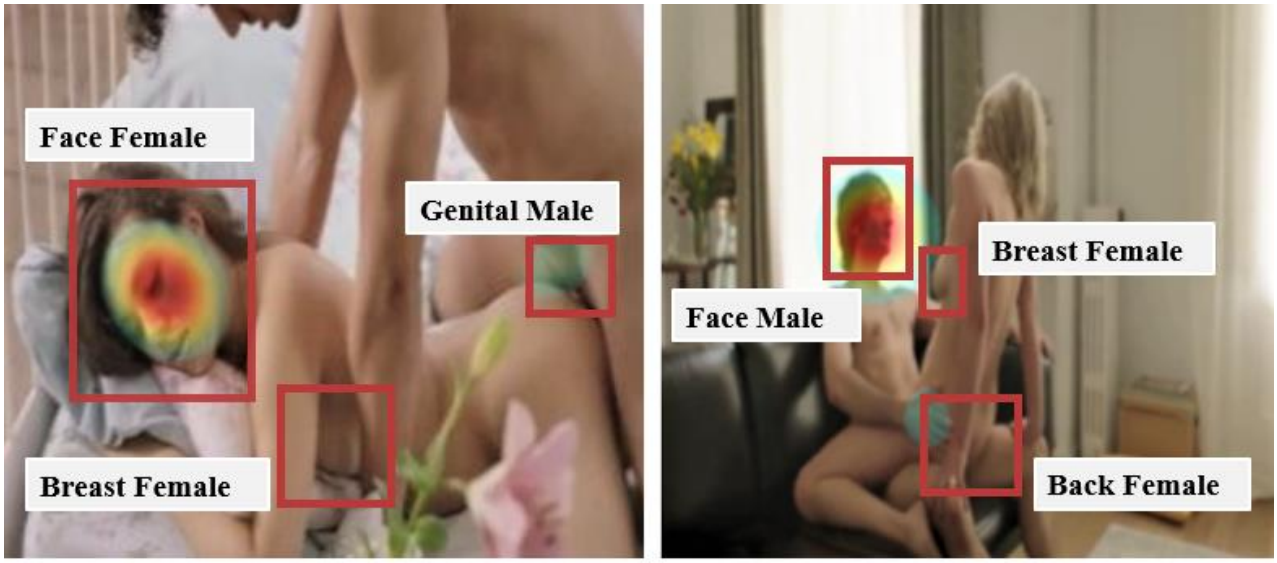
Experiment 1: Erotic videos

Experiment 1 consisted of six erotic videos. Duration of each trial varied between 12 – 27 seconds, and the entire task took approximately 15 minutes. Fifty-four other videos were used as fillers in the experiment, and they contained different types of content: such as violence, pain, and social interaction. These videos were excluded from the analysis in this study. Dynamic regions of interest (ROIs) were drawn frame-by frame on the face, breast, genital, and buttocks (back) areas of the male and female characters in the erotic scenes. Examples of the ROIs are shown in Figure 1.

Before the task, participants were explained that they were going to see videos with variable content. They were instructed to watch videos as they were watching Netflix or other content on a computer. Before the task the eye tracker was calibrated with a standard nine-point routine. The accepted average error was less than 1.0. After calibration the experiment began. Drift

check was performed at the beginning of the experiment and after each quarter of the experiment (approx. after each 4 minutes of task). Besides the drift check there were no pauses during the task.

Figure 1 Sample stimulus frames illustrating representative ROIs. The overlaid heatmaps show mean fixation distribution during the frame.



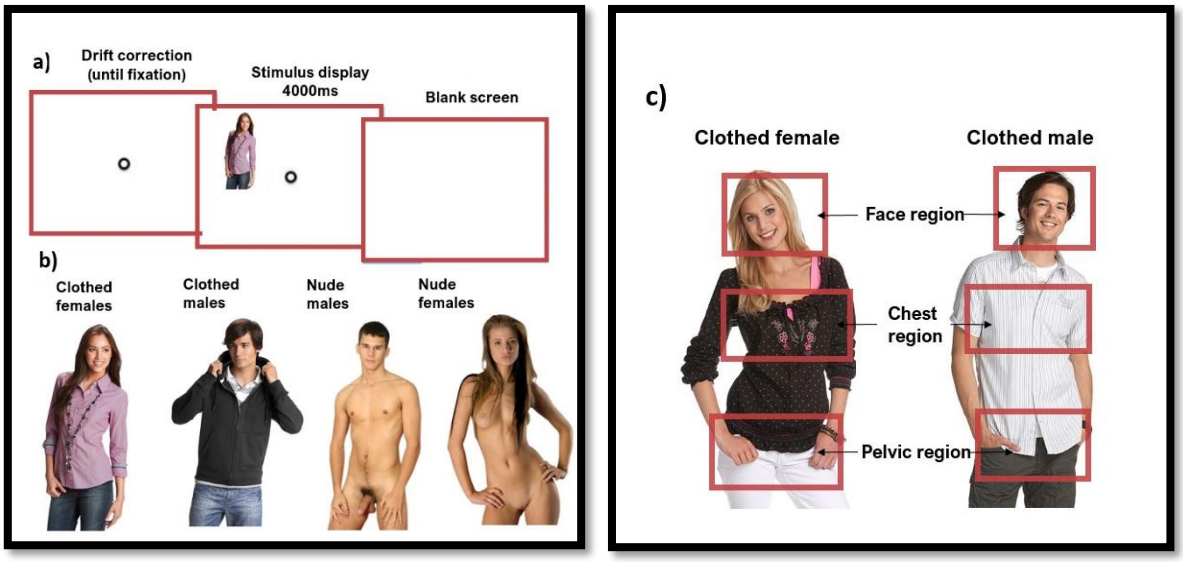
Experiment 2: Static images

Experiment 2 addressed the sex differences in viewing of controlled static erotic stimuli. There were altogether 52 stimuli shown on separate trials. There were four types of stimuli: photographs of nude or clothed adult males and female (see illustration in Figure 2.2). The stimuli have been validated and described in detail previously (Nummenmaa et al., 2012). On each trial a single picture was shown for four seconds. The location of the presented stimuli on the screen varied within each trial. Stimuli could appear on the left or right bottom/top corner of the screen. Drift check target was presented in the centre of the screen, and it was checked before each trial. The trial structure is illustrated in Figure 2.

Participants were instructed to evaluate the valence and arousal of each stimulus on a scale ranging from 1 to 9. The valence scale measured how avoidable (1) or approachable (9) the stimulus was and the arousal scale measured how calm (1) versus aroused (9) they felt while viewing the stimuli. The evaluation was performed immediately after each trial and it was followed by the drift correction and next stimulus pair. The accepted average error for calibration was less than 1.0. Before the actual trials the participants were presented with four practice trials to confirm they had understood the task. The practice session began after the

eye-tracker was calibrated successfully. The whole experiment lasted approximately 15 minutes.

Figure 2 Illustration of the trial events (a), experimental stimuli (b) and c) regions of interest in Experiment 2.



Data analysis

The data analysis was performed with R statistics. In Experiment 1 we computed two eye movement metrics. Mean gaze duration for each ROI was defined as (1) *trialwise proportional dwell time (%),* and (2) pupil size was indexed as the *average pupil size* for each ROI. The eye movement data were analysed with a 2 (Subject sex: Male vs. Female) x 8 (ROI: Face Male vs. Face Female vs. Breast Female vs. Breast Male vs. Back Female vs. Back Male vs. Genital Female vs. Genital Male) ANOVA. The p-values were corrected with Greenhouse-Geisser because the assumption of sphericity was not met with Mauchly's test of sphericity, and two-tailed alpha level of $p < .05$ was used in all analyses. The multiple comparisons were analysed with pairwise post-hoc analyses and corrected by using the Bonferroni procedure.

In Experiment 2 we computed the means for (1*) dwell time* (gaze duration)*, (2) first fixation latency (latency of the very first fixation on the trial landing on a ROI)* (3) *first fixation time* (duration of the first fixation landing on a ROI), and (4) *average pupil size* for each ROI. The data were analysed with a linear mixed model (LMM) analysis. Like Experiment 1, the multiple comparisons were analysed with pairwise post-hoc analyses and corrected by using the Bonferroni procedure. Two-tailed alpha level of $p < .05$ was used in all analyses.

To clarify the interpretation of the results, we use term *sex* for the gender of the participant and term *gender* for the gender of the stimulus.

Results

Experiment 1

The ANOVA results for dwell time (mean) and the average pupil sizes are summarised in Table 3.

Table 3 ANOVA results of the ROI data in sexual scenes of the dwell time and pupil size. Significant results are bolded.

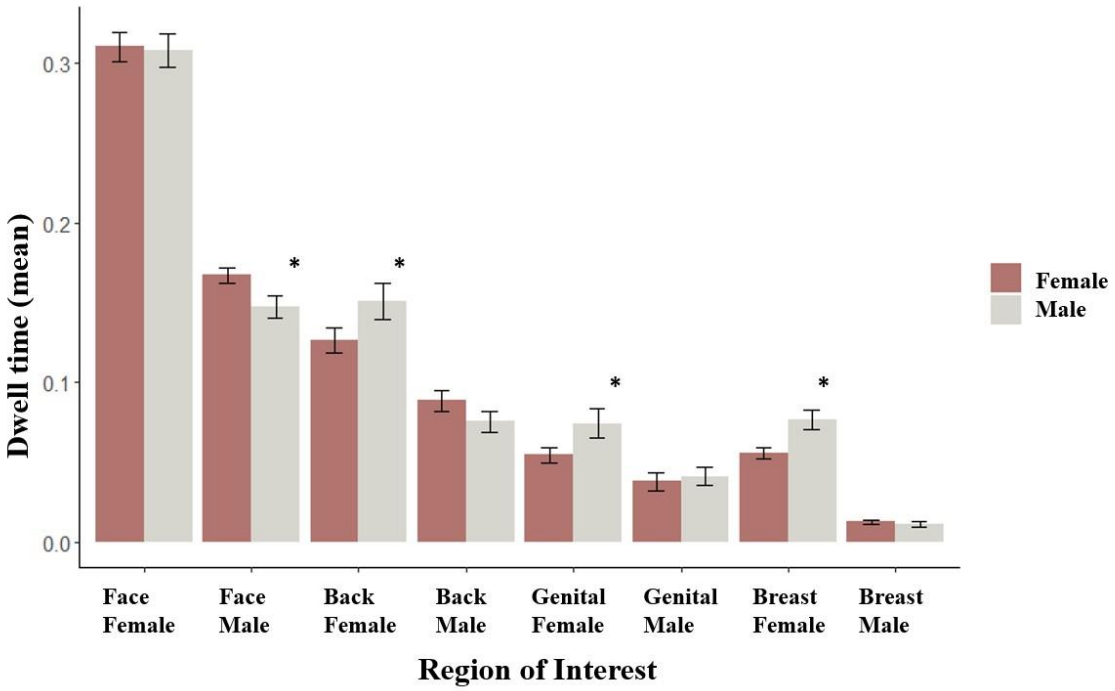
Source	df	*F*	ges	*p*
Dwell time (mean)				
Subject sex	1,108	1.022	0.002	.314
ROI	7,756	**33.905**	**0.207**	**3.642^{e-41}**
Subject sex X ROI	7,756	**3.00**	**0.023**	**4.117^{e-3}**
Average pupil size				
Subject sex	1,108	1.121		.292
ROI	7,720	1.327		.234
Subject sex X ROI	7,720	1.580		.138

df = degrees of freedom, ges = generalized eta squared
** p-values corrected with Greenhouse-Geisser because the assumption of sphericity wasn't met with Mauchly's test of sphericity*

Dwell time analysis on regions of interest

The ANOVA revealed main effect of the ROI, showing that the dwell time differed between different ROIs ($p < .001$, $ges = 0.207$). Main effect was not found for the Subject sex ($p = .314$, $ges = 0.002$). As illustrated in Figure 3, female faces were looked at longest by all, regardless of the subject sex. In turn, male's breasts were looked at for shortest duration. In all regions of interest, female character was viewed more when compared to males.

Figure 3 Dwell time as a function of ROI and Subject sex (***** = *$p < 0.05$ in contrast test).*



There was also an interaction effect of Subject sex X ROI (p <.05, *ges*= 0.023). Pairwise post-hoc tests, illustrated in Table 4, revealed that statistically significant sex-related differences were discovered in four regions of interest. Female participants viewed more male faces than male participants ($p < 0.05$, *Cohen's d* = -0.408). Instead male participants looked female back ($p < 0.05$, *Cohen's d* = 0.505), genitals ($p < 0.05$, *Cohen's d* = 0.412) and breasts ($p < 0.05$, *Cohen's d* = 0.432) longer than females.

Table 4 Pairwise post-hoc tests and effect sizes (*Cohen's d*) for the subject sex in different ROIs in Experiment 1. Significant results are bolded. [Confidence level 0.95]

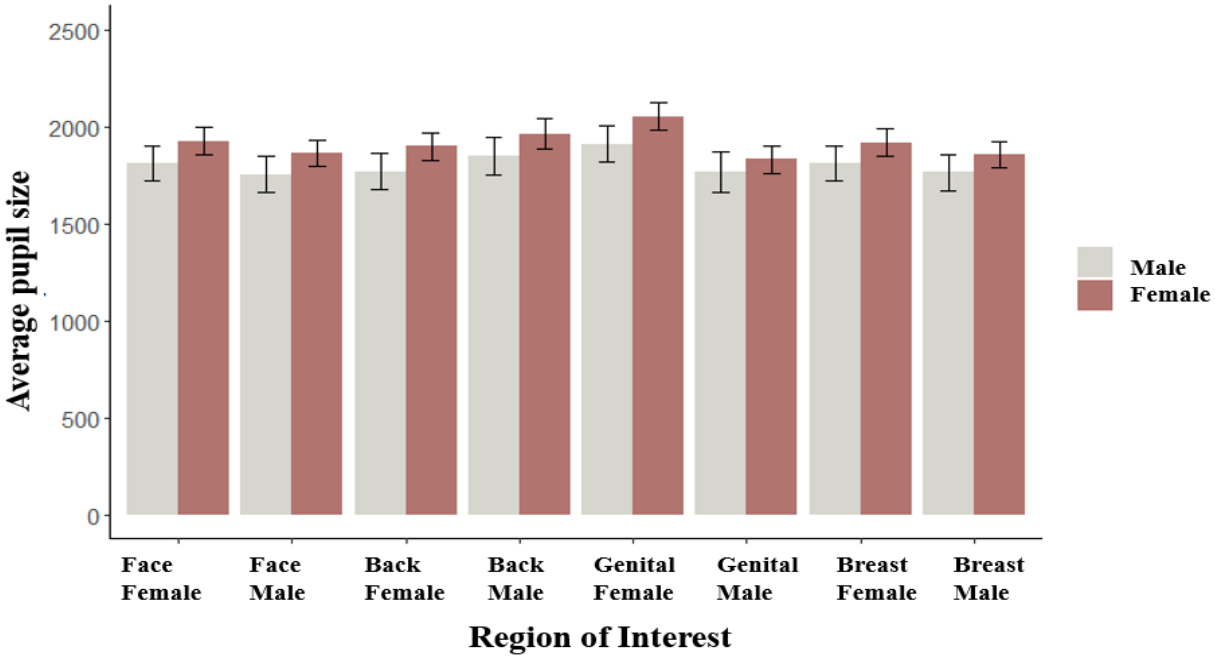
Source	Estimate	*SE*	*p**	*Cohen's d*
Dwell time (mean)				
Face Female	-0.0024	-0.0097	.804	-0.049
Face Male	-0.0197	-0.0097	**.042**	**-0.408**
Back Female	0.0244	0.0097	**.012**	**0.505**
Back Male	-0.0129	0.0097	.183	-0.267
Genital Female	0.0199	0.0097	**.040**	**0.412**
Genital Male	0.0032	0.0097	.744	0.065
Breast Female	0.0208	0.0097	**.032**	**0.432**
Breast Male	-0.0012	0.0097	.903	-0.024

**p-values are corrected with Bonferroni procedure*

Pupil size analysis

As seen in Table 3, the ANOVA didn't reveal significant differences in pupil sizes between male and female participants. Female pupils were consistently larger than male in every ROI, but the difference was not significant (p = .292). There was no main effect for ROI (p = .234). nor an interaction effect for Subject sex X ROI (p = .138). Average pupil size data are illustrated in Figure 4.

Figure 4 Average pupil size as a function of ROI and Subject sex



Experiment 2

Self-report Scores

Table 5 Mean scores and standard deviations for arousal and valence of the nude and clothed stimulus

	Clothed		**Nude**	
	M	*SD*	*M*	*SD*
Valence				
Male	5.12	2.03	5.29	2.05
Female	5.17	2.05	5.18	2.06
Arousal				
Male	3.09	1.92	3.06	1.88
Female	2.98	1.93	3.02	1.93

Absolute range, 1-9

The scores for valence and arousal, presented in Table 5, were similar between nude and clothed stimuli. Nude male stimuli received higher points than nude female stimuli on both valence (M_{male} = 5.29, M_{female} = 5.18) and arousal (M_{male} = 3.06, M_{female} = 3.02), but the differences were small and not significant.

Eye Movement Measures

The ROI data were analysed with a linear mixed model (LMM) and the statistically significant results are summarised in Table 6. The analysis was performed for dwell time (%), first fixations, first fixation times and the average pupil sizes. Pairwise post-hoc analyses were performed to qualify the interactions.

Table 6 Statistically significant results of the Experiment 2 in dwell time (%), first fixation, first fixation duration and average pupil size. Significant results are bolded.

Source	***df***	***F***	***p***
Dwell time (%)			
FACE region:			
Subject sex	1,1030	.451	.504
Clothing	**1,4982**	**49.431**	**2.333^{e-12}**
Stimulus gender	1,4982	3.031	.082
Subject sex X Clothing	1,4982	2.500	.114
Subject sex X Stimulus gender	**1,4982**	**4.064**	**.043**
Clothing X Stimulus gender	1,4982	1.600	.201
Subject sex X Clothing X Stimulus gender	1,4982	1.576	.209
CHEST region:			
Subject sex	1,105	3.417	.067
Clothing	**1,4984**	**51.768**	**7.176^{e-13}**
Stimulus gender	**1,4984**	**19.230**	**1.182^{e-5}**
Subject sex X Clothing	**1,4984**	**6.973**	**.008**
Subject sex X Stimulus gender	1,4985	.026	.873
Clothing X Stimulus gender	**1,4984**	**5.422**	**.019**
Subject sex X Clothing X Stimulus gender	1,4985	.251	.617
PELVIC region:			
Subject sex	1,105	1.036	.311
Clothing	**1,4984**	**39.580**	**3.419^{e-10}**
Stimulus gender	1,4984	.044	.834
Subject sex X Clothing	**1,4984**	**34.626**	**4.256^{e-9}**
Subject sex X Stimulus gender	1,4984	1.253	.263
Clothing X Stimulus gender	1,4984	3.763	.052
Subject sex X Clothing X Stimulus gender	**1,4984**	**8.152**	**.004**
First fixation			
FACE region:			
Subject sex	**1,101**	**4.520**	**.036**
Clothing	1,4218	.102	.749
Stimulus gender	1,4218	2.121	.145
Subject sex X Clothing	**1,4218**	**19.394**	**1.089^{e-5}**
Subject sex X Stimulus gender	1,4218	1.803	.179
Clothing X Stimulus gender	1,4219	1.714	.191

Subject sex X Clothing X Stimulus gender	1,4219	1.410	.235
CHEST:			
Subject sex	1,104	.047	.830
Clothing	1,3729	.006	.939
Stimulus gender	1,3719	.213	.645
Subject sex X Clothing	1,3732	.902	.342
Subject sex X Stimulus gender	1,3721	1.416	.234
Clothing X Stimulus gender	1,3713	.003	.955
Subject sex X Clothing X Stimulus gender	1,3716	.351	.553
PELVIC region:			
Subject sex	1,103	2.475	.119
Clothing	1,3218	3.010	.083
Stimulus gender	1,3178	.194	.660
Subject sex X Clothing	**1,3218**	**16.633**	**4.645^{e-5}**
Subject sex X Stimulus gender	1,3174	3.340	.068
Clothing X Stimulus gender	1,3169	2.104	.147
Subject sex X Clothing X Stimulus gender	1,3168	.805	.370
First fixation duration			
FACE region:			
Subject sex	1,98.5	1.805	.182
Clothing	1,4214	.860	.354
Stimulus gender	1,4214	2.154	.142
Subject sex X Clothing	**1,4213**	**4.723**	**.029**
Subject sex X Stimulus gender	1,4214	1.361	.243
Clothing X Stimulus gender	1,4215	2.750	.097
Subject sex X Clothing X Stimulus gender	1,4215	1.198	.273
CHEST region:			
Subject sex	1,104	.069	.794
Clothing	**1,3729**	**5.091**	**.024**
Stimulus gender	1,3719	1.200	.273
Subject sex X Clothing	1,3732	.699	.403
Subject sex X Stimulus gender	1,3722	.479	.489
Clothing X Stimulus gender	1,3714	.002	.962
Subject sex X Clothing X Stimulus gender	1,3717	.023	.279
PELVIC region:			
Subject sex	1,101	.379	.560
Clothing	1,3208	2.772	.096
Stimulus gender	1,3172	.361	.548
Subject sex X Clothing	**1,3207**	**24.166**	**9.284^{e-7}**
Subject sex X Stimulus gender	1,3168	.125	.723
Clothing X Stimulus gender	1,3165	.781	.377
Subject sex X Clothing X Stimulus gender	1,3164	.005	.944
Average pupil size			
FACE region:			
Subject sex	1,105	.000	.984
Clothing	**1,4214**	**4.607**	**.032**
Stimulus gender	**1,4214**	**8.308**	**.004**
Subject sex X Clothing	**1,4214**	**3.950**	**.047**
Subject sex X Stimulus gender	**1,4214**	**20.378**	**6.529^{e-6}**
Clothing X Stimulus gender	1,4214	.519	.471
Subject sex X Clothing X Stimulus gender	1,4214	2.017	.156
CHEST region:			
Subject sex	1,105	.000	.989
Clothing	1,3704	.192	.662

Stimulus gender	**1,3703**	**8.026**	**.005**
Subject sex X Clothing	1,3703	.072	.789
Subject sex X Stimulus gender	**1,3703**	**30.013**	**4.577^{e-8}**
Clothing X Stimulus gender	1,3703	.253	.615
Subject sex X Clothing X Stimulus gender	1,3703	1.349	.246
PELVIC region:			
Subject sex	1,105	.008	.929
Clothing	1,3154	.848	.357
Stimulus gender	**1,3153**	**14.268**	**.000**
Subject sex X Clothing	1,3153	.472	.492
Subject sex X Stimulus gender	**1,3153**	**26.851**	**2.336^{e-7}**
Clothing X Stimulus gender	1,3153	1.09	.297
Subject sex X Clothing X Stimulus gender	1,3153	.897	.344

Dwell time analysis

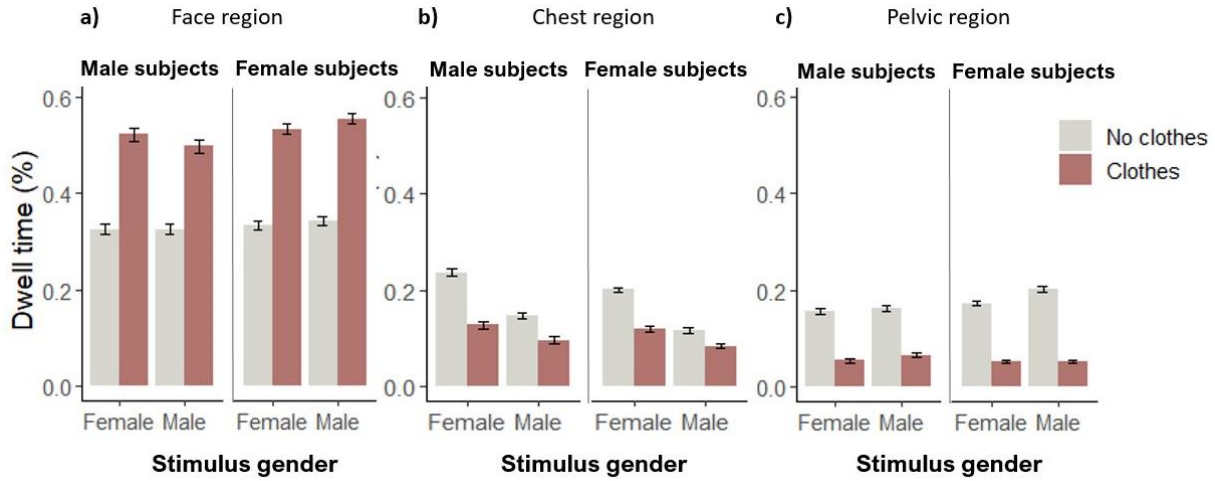
Overall, the results revealed that dwell times differed across ROIs and that faces received most attention (see Figure 5). The main effect of the clothing was significant in every ROI: Clothed stimuli's faces were viewed longer than nude's ($p < 0.001$), but instead both the chest region ($p < .001$), and the pelvic region ($p < 0.001$) were viewed longer when the stimuli were nude. Stimulus gender's main effect was revealed in chest region ($p < .001$), and both male and female subjects viewed female chest area longer than male chest area.

There was also an interaction effect of Subject sex X Stimulus gender ($p < 0.05$) in face region. Pairwise post-hoc analysis revealed no statistically relevant effects, but male subjects viewed more female faces ($p = .249$, *Cohen's d* = .051) and female subjects viewed more male faces ($p = .07$, *Cohen's d* = -.064). In the dwell time for chest region, there was also an interaction between Clothing X Subject sex ($p < .05$). Male subjects viewed chest area on naked stimuli longer than for clothed stimuli ($p < .0001$, *Cohen's d* = .535). The results for female participants were similar ($p < .0001$, *Cohen's d* = .384). There was also a significant interaction between Clothing and Stimulus on the chest area ($p < .05$). Nude female chest area was viewed longer than clothed female chest ($p < .0001$, *Cohen's d* = .638). Similar results were seen in the dwell time of male chest area ($p < .0001$, *Cohen's d* = .280), but the effect was smaller.

Pelvic region analysis showed an interaction between Subject sex and Clothing ($p < 0.001$). As for the chest area, nude pelvic area was viewed more than clothed pelvic area by both male ($p < .0001$, *Cohen's d* = .935) and female subjects ($p < .0001$, *Cohen's d* = 1.271). Finally, there was an interaction between Subject sex, Clothing and Stimulus gender ($p < 0.01$). This three-way interaction revealed the different effect of the clothing on dwell times for female and male

stimuli. Nudity increased the viewing time of male stimuli's pelvic region within female subjects, but not with male subjects ($p < .0001$, *Cohen's d* = 1.421).

Figure 5 Means and SD of the dwell times for face (**a**), chest (**b**) and pelvic (**c**) region.

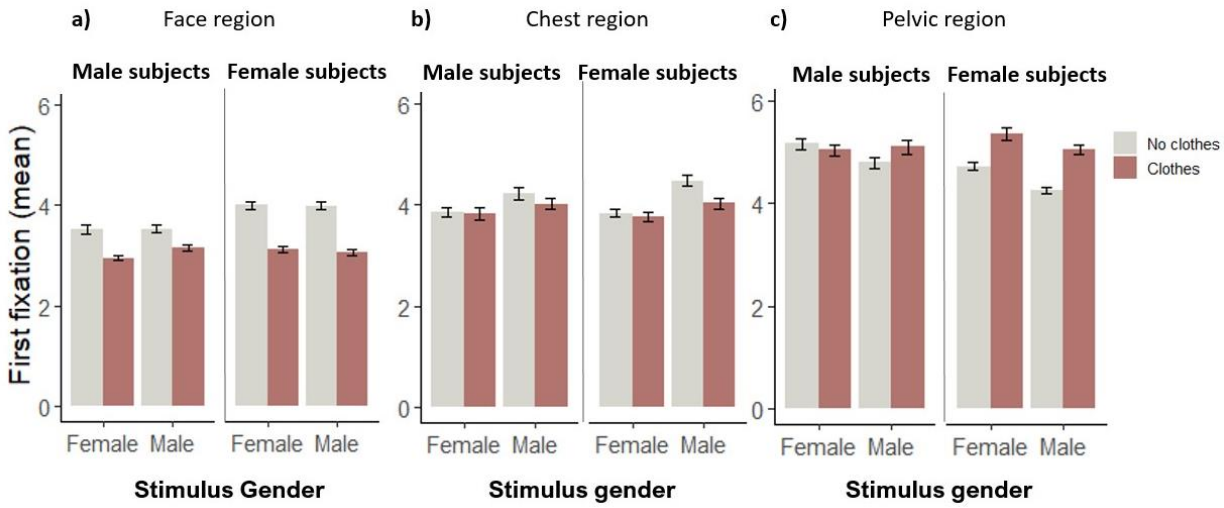


First fixation analysis

Results for the first fixation analysis are illustrated in Figure 6. Results of the face region showed that only the Subject sex had main effect on the first fixations ($p < 0.05$) and that male subjects viewed stimulus face earlier than female subjects. There was also a statistically significant interaction between Subject sex and Clothing ($p < 0.001$). Faces of the clothed stimulus were observed earlier by both male ($p < .0001$, *Cohen's d* = 0.307) and female subjects ($p < .0001$, *Cohen's d* = 0.580) than nude stimulus. The effect was stronger within the female subjects.

There were no significant differences in first fixations in the analysis of chest area, and the only statistically significant interaction was Subject sex X Clothing ($p < 0.001$). Female subjects viewed pelvic area of the nude stimulus faster than when stimulus was clothed ($p < .0001$, *Cohen's d* = -0.401), the same effect was not seen in male subjects ($p = .130$, *Cohen's d* = -0.09).

Figure 6 Means and SD of the first fixations for face (**a**), chest (**b**) and pelvic (**c**) region.

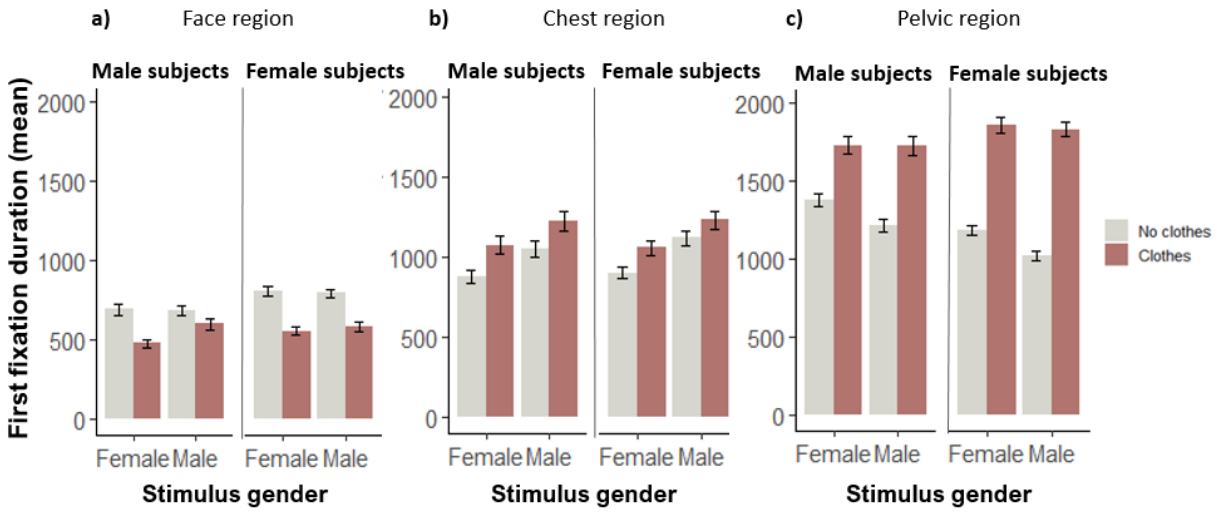


First fixation duration analysis

First fixation duration analysis on the face region revealed a statistically significant interaction between Subject sex and Clothing ($p < 0.05$). Male subjects' first fixation durations were longer for nude stimuli ($p < .0001$, *Cohen's d* = 0.307) when compared to clothed stimuli. Similar results were found for female subjects *(*$p < .0001$, *Cohen's d* = 0.580) and the effect was numerically even stronger. In the chest region analysis, main effect was found for clothing of the stimulus ($p < 0.05$). As illustrated in Figure 7, first fixation durations were longer for clothed stimulus in comparison to nude stimulus.

A significant interaction of Subject sex X Clothing was found for the pelvic region ($p < 0.001$). While both sexes spent more time of first fixation on clothed pelvic regions, female subjects had a greater difference between nude and clothed stimuli ($p < .0001$, *Cohen's d* = -0.964). than male subjects ($p < .0001$, *Cohen's d* = -0.588).

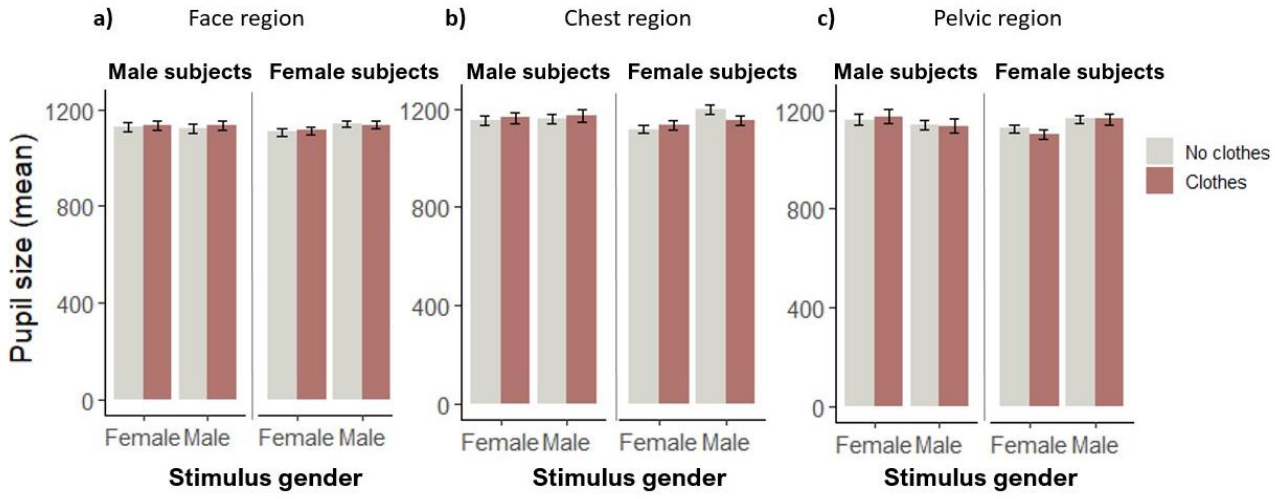
Figure 7 Means and SD of the first fixation duration for face (**a**), chest (**b**) and pelvic (**c**) region.



Pupil size analysis

In the pupil size analysis, interaction of Subject sex X Stimulus gender was found for all three regions: face ($p < 0.001$), chest ($p < 0.001$) and pelvic region ($p<0.001$). This was seen systematically in the size of female pupils, which were larger when the viewed male stimulus' face ($p < .0001$, *Cohen's d* = -.262), chest ($p < .0001$, *Cohen's d* = -.417) and pelvic region ($p < .0001$, *Cohen's d* = -.304). The analysis of face region revealed a main effect of the Clothing ($p <.05$). Pupils were larger while viewing the face of nude stimulus than clothed stimulus. Interaction between Subject sex X Clothing was discovered in the pupil size analysis of face region ($p < 0.05$). Male subjects' pupils were larger when they viewed clothed stimuli versus nude stimuli ($p < .05$, *Cohen's d* = -0.099), but the effect remained small. These results are shown in Figure 8.

Figure 8 Means and SD of the pupil sizes for face (**a**), chest (**b**) and pelvic (**c**) region.



Discussion

The aim of this study was to investigate sexual perception in the dynamic and static stimuli experiments. Our main finding was that the face area was the most attention-catching and thus important area while viewing both static and dynamic erotic stimuli. This was seen in both experiments. Regardless of the clothing or the sex of the participant, the dwell time of face area was longest when compared to other areas. Sex-specific differences were also discovered: In the dynamic stimuli experiment male participants viewed female breasts, genitals, and buttocks statistically significantly longer than females, while female participants allocated more attention to male faces than male participants. In Experiment 2, the main effects on the gaze patterns were mostly related to clothing of the stimulus and both male and female participants viewed nude stimuli differently than clothed stimulus. Nude stimuli were viewed more thoroughly, which was also reflected in diminished dwell times and in shorter first fixation times on facial area. Pupil size analysis were contradictory between the two experiments. While pupils did not seem to differ in size while watching dynamic stimulus, significant differences were found in the experiment with static images. Particularly female participants' pupils were larger while watching male stimulus in every interest area when compared to watching female stimulus.

What attracts attention in human bodies?

Consistent with the previous studies, faces received most of the attention even for the nude stimuli. This was seen for the dwell time, which was longest on faces for both experiments, and in the latency of first fixations, which were shortest for faces. Same phenomenon has been consistently found in prior studies (Lykins et al., 2006; Nummenmaa et al., 2012; Tsujimura et al., 2009). This confirms that the face area is important also in sexual context. This may relate to the fact that faces are an important source of fitness and overall health (Rhodes, 2006). The importance of face might also be explained by the communicational value: We read nonverbal cues from faces, and it is known to be an important area for social engagement (Ishii et al., 2018). Finally, it could relate to affective communication during sexual intercourse, as multiple studies have discovered that communication and sexual satisfaction are closely linked to each other (Kelly et al., 2006; Montesi et al., 2011; Purnine & Carey, 1997). Thus, close attention to partner's facial responses during intercourse could be an important mechanism for sampling partner's sexual satisfaction.

After the face area, fixations were drawn to the chest area and finally on the pelvic area, suggesting a head-to-toes processing of static human figures. This was seen in the first fixation analysis of Experiment 2. Additionally, we discovered that the clothing of the stimulus had the largest effects on the gaze patterns. Faces were inspected earlier for clothed stimuli in comparison to nude stimuli. Additionally, according to the dwell time analysis, attention was drawn mainly to face region when the stimuli were clothed. When the stimulus was nude, dwell times for face region decreased. This was seen in later first fixations and diminished dwell times on faces in Experiment 2. According to the first fixation time analysis the inspection of the stimulus was faster on nude bodies, which was seen in diminished gaze durations in the chest and pelvic regions. Additionally, the durations of the first fixations were longer on pelvic and chest regions of the stimulus on both clothed than nude bodies. Also, the duration differences were longer between face and other regions when stimulus was clothed, which might reflect the more precise inspection of the body when the visual cues of the physical attractiveness are not available due to clothing.

These results from the static images experiment replicate prior findings using exactly the same paradigm (Nummenmaa et al., 2012), where clothing had also a strong effect on gaze patterns. Although in our study, statistically significant differences were not discovered for mean valence and arousal scores for male and female stimuli (Table 5). This might be explained by the fact that male and female participants' scores were not considered separately. Also Lykins et al (2006) observed longer total dwell times for bodies in nude stimuli when compared to clothed stimuli. The impact of the clothing to the gaze patterns came out as predicted. Additionally the observed difference between the processing of erotic and non-erotic material accords previous findings (Fromberger et al., 2012; Lykins et al., 2006; Nummenmaa et al., 2012) indicating the fact that nude bodies, as well as faces, serve as valuable source of physical attraction.

Sex-specific differences in gaze patterns

Similarly to previous studies, we discovered statistically significant sex differences in the perception of erotic stimuli. Experiment 1 revealed that male participants looked more at female chest, buttocks and genital areas in comparison to female participants. Similar findings regarding the female chest area were reported in one previous study with static images (Nummenmaa et al., 2012). In addition, we discovered that female participants differed from males in that they allocated more attention to the facial area (Experiment 1). This result was

also reported in Nummenmaa and colleagues' study. Their finding of female participants viewing significantly longer male's pelvic area than males was however not replicated in our experiment with dynamic stimuli. Instead, we found that both sexes however viewed more female bodies than male bodies, possibly reflecting the strong bottom-up nature in processing cinema (Hasson et al., 2010).

In turn, the static image experiment showed that the facial area of the opposite sex was more interesting: This was seen in the dwell time analysis as the subjects viewed more opposite-sex stimulus faces than same sex faces. Male subjects also viewed face regions of the stimuli sooner than females, which was seen in first fixations. Finally, female subjects were more interested in the nude men's pelvic area than same-sex pelvic area. There were also similarities in the Experiment 2 between male and female participants. Both genders were more interested in the chest region of female stimuli. This was also seen in Nummenmaa and colleagues' study (2012). The importance of the female chest region might be explained from the perspective of reproduction, as the breast size is known to be a significant cue of fertility (Jasieńska et al., 2004). These results support the fact that sexual information is processed visually in different way by men and women (Lykins et al., 2008; Rupp & Wallen, 2007). Males tend to be more interested in females and vice versa, although this has not been so clear for the female sex in the previous studies: It has been reported that men view preferentially woman sex figures while women looked more equally both genders (Fromberger et al., 2012; Lykins et al., 2008; Nummenmaa et al., 2012; Tsujimura et al., 2009).

Pupil size analysis

Significant differences in the average pupil size were only seen in the static image experiment: Female subjects' pupils were larger when they viewed male stimulus, and the difference was seen in every region of interest. This might indicate the attraction to opposite sex on female subjects, as the previous studies have discovered that the pupil dilation is a significant indicator of sexual orientation and arousal (Rieger & Savin-Williams, 2012). Yet, the same effect was not seen in the male subjects, but male subjects' pupils were larger when they viewed face region of the clothed stimuli. Additionally, in the erotic videos female participants' pupils were systematically larger than males', but the difference was not statistically significant.

It should be noted that the unit of the pupil size was not quantified in our study. It was only used for the comparison analysis of the size. Also, the notable differences in the average pupil

size between Experiment 1 and Experiment 2 was probably due to the different backgrounds for the stimulus type, as the static picture stimuli were viewed with a white background which typically makes pupils smaller (Figure 2). Acknowledged problems in pupil dilation measurements, as lightning, subject factors (e.g. age, drowsiness, arousal) and blinking, should also be considered in the evaluation of the results (Arch, 1979).

Dynamic videos vs. Static images

Finally, our aim was to investigate the sexual perception of the dynamic stimuli and compare the results with the static stimuli results. Although the different experimental designs make direct statistical comparisons impossible, we can nevertheless assess the general pattern of the statistical results observed in each study. Previous preliminary study discovered, that the sex differences seen in picture experiments were not found in the viewing patterns of sexual videos (Tsujimura et al., 2009). On the contrary, our results of the erotic video experiment revealed specific gaze patterns and sex-specific differences.

When the results of the two experiments were compared, both similarities as well as differences were discovered. Both experiments highlighted the importance of the face region and attraction to the female breasts for both sexes. Yet, different patterns were found, for example, in the male interest for female genitals, which were seen in the video experiment's results but not in the picture experiment. In general, there were more sex-specific differences in the gaze patterns in the dynamic stimulus experiment. Male subjects were more interested in the female bodies in every region of interest, but the same effect was not seen in the static picture experiment. This might indicate the more real-life representative nature of dynamic stimulus and reveal the known differences in sex drive between males and females (Baumeister et al., 2001). These findings are relevant and support the fact that videos evoke higher levels of arousal and might therefore produce more authentic patterns of visual attention (Julien & Over, 1988).

Strengths and limitations of the study

The sample size of the study was large and there was a good balance in participant sex. We also ran two experiments with two different types of erotic stimuli and extended the studies on sexual perception of static images to that of dynamic, naturalistic videos. Comparing the results from two tasks gave us valuable information of the differences in reading sexual signals of static images and dynamic videos. Especially, they highlight the importance of gaining insight

into the dynamic sexual stimulus perception is valuable and already previously recognized in the field of science (Tsujimura et al., 2009; Wenzlaff et al., 2016).

There are also some limitations, which should be noticed when evaluating the effectivity of the results. First, most of the participants were university students and highly educated so the results may not directly translate to other education levels. Second, the sexual orientation of the participants was measured with the attraction scale for different sexes (see Table 1.2). Female participants' mean attraction to men (M = 83.4) was distinctly higher than the attraction women (M = 33.7). The opposite results were found in male participants' data (M_{women} = 89.8, M_{men}= 16.3). Considering that the standard deviations were notable in both genders (SD = [20.2 - 27.9]), it must be taken into account that the sample was not purely heterosexual in our study, only 16 of the participants (14,5%) answered to be purely heterosexual (attraction to opposite sex = 0). This might have an impact to the results because we cannot conclude whether the sex-dependent eye movement differences between individuals relate to sex versus sexual orientation.

Sexual orientation has been noticed and considered in many studies, for example by studying only heterosexual participants (Fromberger et al., 2012; Lykins et al., 2008; Nummenmaa et al., 2012). However, finding subjects with exactly zero sexual attraction to one's own sex might not be likely in the first place. Accordingly, we stress that our interest was not in sexual orientation dependent but sex-dependent gaze patters. Third, some proof of female's hormonal profile's impact to the gaze patterns has been discovered, and it has been considered in the previous study (Rupp & Wallen, 2007). The contraceptive use or the menstrual phase were not taken into account in our study.

Additionally, one factor possibly affecting to the results is social desirability. Being aware that one's eye movements are precisely followed might change the way of viewing stimuli, especially when it comes to intimate topics as sexual interaction or nudity. As the problem has been noted in the sexual behaviour surveys (King, 2022), it might as well affect to the results in eye-tracking studies. Finally, the main limitation in the statistical analysis is that there are no effect sizes for all the static experiment results. This is due to the non-existent universally approved effect sizes for the linear mixed model analysis.

Conclusions

Faces and bodies are important cues of physical attraction and nonverbal communication. In our study, both image and video experiments revealed the importance of the facial area and the sex-related differences in the visual processing of erotic stimulus. Variation in the clothing of the stimulus had an impact on the gaze patterns, and nude bodies were inspected more thoroughly. These findings underlie the importance of faces in the social engagement and the fact that bodies are significant indicators of physical attractiveness of a potential mating partner. Our results accord with previous studies, and this study gave new valuable information of the sexual perception of dynamic stimulus. The results suggest that the visual processing of dynamic stimulus differs from the processing of picture stimulus. Yet, more studies are needed in the future to achieve more evidence on the findings, which suggest that erotic videos reveal more authentic information of sexual perception.

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