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To cite this article: Oliver Lee Eric Jacobs, Farid Pazhoohi & Alan Kingstone (2023): Contrapposto posture captures visual attention: An online gaze tracking experiment, Visual Cognition, DOI: 10.1080/13506285.2023.2213904

To link to this article: https://doi.org/10.1080/13506285.2023.2213904

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Published online: 22 May 2023.

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Contrapposto posture captures visual attention: An online gaze tracking experiment

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ABSTRACT
Goddesses of love and beauty are frequently depicted in artwork in a contrapposto posture with one leg relaxing while the other bears the weight. Previous research has indicated that compared to an upright standing pose, a contrapposto pose is considered more attractive with its curviness capturing greater visual attention. Yet, whether a body posed in contrapposto is generally more visually attention-grabbing than an upright body remains unknown. We sought to address this gap and also examined if individual differences in sociosexuality – individual differences in willingness to engage in uncommitted sexual relations – influence attentional allocation. Online gaze-tracking was employed to monitor subjects (n = 71) during image presentation in a preferential looking design (contrapposto verse standing). Participants had a greater proportion of their gaze directed towards female bodies depicted in contrapposto pose compared to a standing posture over an extended period of time but not in the first gaze shift. Moreover, sociosexuality correlated positively with the proportion of gazes towards contrapposto stimuli but fell short of statistical significance. The results of the current study indicate that top-down factors play a role in how people allocate more attention to contrapposto poses.

1. Introduction
A low Waist-to-Hip Ratio (WHR) in women is often perceived as an indicator of a female’s reproductive value and sexual maturity (Symons, 1995), and is thus also associated with attraction (Lassek & Gaulin, 2019). When posing in a contrapposto posture, that is, an asymmetric body posture in which one leg relaxes while the other one bears the weight, women’s WHR on one side of the body is markedly lower. This can be considered a supernormality effect that attracts attention to the curvier side and heightens the perception of attractiveness (Pazhoohi, Macedo, et al., 2020). The contrapposto posture has also been shown to trigger greater neural activity than a standing pose in brain regions associated with perception and judgments of attractiveness (Pazhoohi, Arantes, et al., 2020).

The higher attractiveness of a contrapposto pose is purportedly a key reason why goddesses of love and beauty are frequently depicted in this posture in artworks (e.g., The Birth of Venus by Sandro Botticelli, Leda and the Swan by Cesare da Sesto, and sculptures of Venus de Milo and Temperance by Giovanni Caccini; Pazhoohi, Macedo, et al., 2020). And while it is known that the “curvier edges” attract greater visual priority, whether a body posed in contrapposto is attentionally more attractive when competing directly with a standing posture is unknown. The current research addresses this issue using a preferential looking task design employing online gaze tracking – a recent technological development that enables real-time gaze analysis through users’ Web-Cameras (Semmelmann & Weigelt, 2018). The purpose of the design is to induce attentional competition requiring participants to display gaze priority to one of the images (Shimojo et al., 2003). These designs have been shown to be effective for quantifying visual priority and teasing apart top-down versus bottom-up visual and cognitive processes (Fecteau et al., 2000; Luck et al., 2021; Will et al., 2021). Top-down visual attention is internally driven by goals and expectations of the observer, while bottom-up visual attention is externally driven by stimulus features in the environment and stimulus scene.

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/13506285.2023.2213904.
relative importance of top-down versus bottom-up processes is critical for understanding the individual component of the contrapposto effect. That is, the degree to which individuals voluntarily allocate their attention to contrapposto poses as opposed to visual attention driven by a greater salience for features of the contrapposto stimuli (Connor et al., 2004). Previous research has repeatedly used top-down versus bottom-up processing in the field of visual cognition (for a review see Luck et al., 2021).

Another advantage of the preferential looking design is that it enables comparisons between individual differences such as sex or sociosexual orientation and any associated visual biases (e.g., Milani et al., 2019). Sociosexual orientation as a personality construct measures individuals’ tendency to engage in casual, uncommitted sexual relationships. For example, individuals with more unrestricted sociosexuality value attractiveness in faces and bodies more compared to sexually restricted individuals (Sacco et al., 2009; Simpson & Gangestad, 1992; Zelazniewicz & Pawlowski, 2011). Accordingly, in this study we explore individuals’ bottom-up versus top-down visual attention as a function of their sociosexuality. Previous research using a forced attention paradigm has shown that attractive faces capture greater visual attention (Leder et al., 2010, 2016; Maner et al., 2003; Mitrovic et al., 2016; Shimojo et al., 2003). Nonetheless, studies investigating visual attention as a function of attractiveness to bodies in a dichotomous design are scarce (e.g., Palmer-Hague et al., 2017). Building on the aforementioned studies demonstrating that contrapposto curves are more attractive (Pazhoohi, Arantes, et al., 2020, Pazhoohi, Macedo, et al., 2020), we can examine if a contrapposto posture will attract more visual attention compared to a standing posture early, for the initial fixation (bottom-up attention) and/or over the course of the trial (top-down attention). Furthermore, by including measures of sex and sociosexual orientation we can assess if and how individual differences modulate attentional commitment to contrapposto stimuli.

2. Method

2.1. Participants

An a priori power analysis conducted using WebPower (Zhang & Yuan, 2018) indicated a required sample size of 84 participants to detect a medium-sized correlation (i.e., $r = 0.3$) between sociosexuality inventory (SOI) scores and gaze proportion to the contrapposto stimuli. A total of 125 individuals in the United States were recruited through Amazon Mechanical Turk in anticipation of losing up to half of the subjects when collecting eye movement data via the participants’ home computers. Of those 125 subjects, 106 completed both the survey and gaze tracking components. As tracking gaze online is less controlled than in-person testing, we applied a rigorous data-filtering threshold (see below), resulting in a final count of 71 participants with a well-balanced distribution of women (35) and men (36) ranging in age from 24 to 76 years of age ($M = 40.46, SD = 11.43$). All participants reported normal or corrected-to-normal vision.

2.2. Stimuli

A 3D female model was created using Daz3D software (www.daz3d.com). The model was posed in contrapposto and standing postures composed of both front and back views. Mirrored images of contrapposto poses were also created to control for which side of the model was curvier. All of the stimuli were cropped from clavicle to knee (see Figure 1 for an example). There were 8 stimuli with each containing a pair of images (one contrapposto and one standing) with one on the left and one on the right. Front and back views were varied between pairs but never within (i.e., both images in a pair faced the front or back). The stimuli were counterbalanced such that contrapposto images appeared an equal number of times on either side and there were an even number of front and back images. Each stimulus was displayed for 10 s.

2.3. Gaze tracking

Gaze position was determined using WebGazer.js which assesses where people are looking based on both the position of the head and the eyes. WebGazer.js is an open-source gaze-tracking library written in javascript that is available to the public (Papoutsaki et al., 2016) and enables real-time gaze location inference via a WebCamera following a programmable calibration sequence. WebGazer was implemented using PsychoPy (Peirce et al., 2019). Though
WebGazer is a relatively new technology, it has been validated for research based on its spatial accuracy and by replicating well-known cognitive effects (e.g., Murali & Çöltekin, 2021; Semmelmann & Weigelt, 2018). WebGazer has a reported resolution of \( \sim 100 \) pixels and a 60 Hz refresh rate.

The calibration sequence requires participants to look at and click their mouse on a box as it appears randomly at one of 30 different locations. From this calibration spatial error estimates are determined for horizontal (x-axis) and vertical (y-axis) positions, and their combined coordinates. Given the design of task and stimuli, our interest is solely on whether people are selecting the left or right image in the horizontal axis. Accordingly, participant exclusion criteria for spatial error was based on the x-axis spatial error. The mean x-error was 140 pixels (SD = 183.77). Participants with an x-gaze error greater than 150 pixels were then excluded based on a previously suggested pixel threshold (Yang & Krajbich, 2021), resulting in a mean x-error of 89 pixels (SD = 87.13). These data were then transformed to produce two dependent variables. The first fixation variable was calculated by taking the mean gaze position of all estimates produced in the first half second interval for each trial. The second dependent variable was the proportion of gaze to the contrapposto or standing stimuli. Gaze proportions were calculated by taking the ratio of observations (or gaze position estimates output by WebGazer) for each of the two images presented on each trial to the total observations for that trial. This was done in order to minimize confounds from sampling rates varying between participants and between trials as has been noted with WebGazer in the past (Yang & Krajbich, 2021). Thus, the resulting data had two gaze proportions for each trial for each participant corresponding to one proportion for the contrapposto stimuli and one proportion for the standing stimuli. A similar method to the first fixation variable could have been produced (calculating the mean position for each trial) but the advantage of the gaze proportion method is that the gaze proportions produced a quasibinomial outcome (e.g., 0.22, 0.55, 0.83) rather than a purely binomial outcome.

2.4. Regions of interest

Participants’ x-axis gaze values (x-observations) were categorized into 3 ROIs (left, right, and centre). The Left and Right ROIs were created to capture the tendency of participants to focus their gaze on either the left or right image being presented. The Center ROI was created to minimize the effect of noise in the gaze tracking by categorizing x-observations that were not clearly falling on either side of the screen. Gaze positions on the centre AOI were excluded for first fixation analyses but were included in the denominator of the gaze proportions as part of the total observations.
The coordinate system of the gaze values mapped onto each participant’s screen such that 0,0 or the origin was always at the centre of the screen. The Center ROI was defined as x-observations that fell between – 50 and 50, while the Left ROI was defined as x-observations that were smaller than – 50. The Right ROI was defined as x-observations greater than 50. These units correspond to pixels on the user’s screen and are variable in real-world size depending on each participant’s screen size and resolution. However, regardless of this variation, negative x-observations always equated to gaze being on the left side of the screen while positive values always indicated gaze on the right side of the screen.

2.5. Sociosexual orientation inventory (SOI)

The revised Sociosexual Orientation Inventory (SOI-R; Penke & Asendorpf, 2008) was used, which is a 9-item scale measuring individuals’ tendency to engage in casual, uncommitted sexual relationships (e.g., “In everyday life, how often do you have spontaneous fantasies about having sex with someone you have just met?”). After reverse-coding one of the items (#6), an averaged score of the items was calculated for each participant.

2.6. Procedure

After agreeing to participate in the task, participants were provided a Qualtrics link. This link led users to a survey containing a detailed ethics consent form (H10-00527). Consenting participants were then asked to answer demographic questions before being asked to write down a unique 5-digit code to enter as their ID for the gaze-tracking component of the study. Participants were then instructed to click on a Pavlovia link wherein they would enter their unique ID to match their Qualtrics and Pavlovia data. Participants were asked to enable WebCamera access and complete a calibration sequence by looking at and clicking on a series of grey boxes appearing randomly one-at-a-time on the screen. After calibration, participants were informed that they would be presented with a series of different pictures that they may view freely but they must click on a grey box after the images disappear. This helped to return participants’ gaze to the centre of the screen before the onset of a trial. When participants had completed all 8 trials, another dialogue box appeared thanking participants for completing the gaze tracking task. Participants were given a completion code and were instructed to return to the Qualtrics survey to enter the code. Finally, participants were asked to answer a SOI-R survey. In total the experiment took approximately 15 min.

3. Results

A generalized linear model (GLM) with a quasibinomial error distribution was fit to the data with the proportion of gaze to the contrapposto stimuli as the dependent variable and facing side of the stimuli (front and back) as a fixed factor. Participant number and trial number were not included as random factors for this and the following models due to convergence issues. The results showed that the intercept was significantly different from zero, \( \beta = -0.188, SE = 0.07, t(566) = -2.68, p = .008 \), but the effect of facing side was not significant, \( \beta = -0.004, SE = 0.10, t(566) = -0.043, p = .966 \). An ANOVA comparison was then used with a chi-square test to compare the model fit with an intercept only model resulting in no significant difference between the models, \( \chi^2(1) <0.001, p = .966 \). Thus, it was determined that the front or back facing stimuli was not an important predictor of gaze proportion to the contrapposto stimuli (see Supplementary Figure 1).

A GLM was also conducted with a Poisson distribution using first fixation location (left or right) as the dependent variable and the side that the contrapposto stimuli was on (left or right) as a fixed factor. The test revealed a significant intercept, \( \beta = 0.929, SE = 0.030, z = 30.60, p<.001 \), but no significant fixed effect of contrapposto side, \( \beta = 0.005, SE = 0.043, z = 0.12, p = .904 \), indicating that the images with contrapposto poses were no more likely to be fixated on first over the standing poses. An ANOVA comparing model fit between the model with contrapposto location and an intercept only model revealed that the model containing contrapposto location was not a better fit above and beyond the intercept only model \( \chi^2(1) = 0.014, p = .905 \).

Next a GLM using a quasibinomial distribution was conducted with gaze proportion as the dependent variable and pose (contrapposto or standing) as a fixed effect. The test revealed a significant intercept, \( \beta = -0.190, SE = 0.049, t(461) = -3.87, p < .001 \), and a
significant fixed effect of pose, $\beta = -0.192, SE = 0.070, t(461) = -2.75, p = .006$. An ANOVA comparing model fits with an intercept only model revealed a significant difference ($\chi^2(1) = -2.565, p = .006$) with the model containing pose as a predictor having significantly more explanatory power. In sum, participants looked significantly more at the contrapposto stimuli compared to non-contrapposto stimuli (see Figure 2).

### 3.1. Sociosexual orientation

A Pearson correlation was used to compare participants’ SOI total and their gaze proportion to the contrapposto stimuli (see Figure 3). The analysis revealed a nonsignificant effect, $r = .19, 95\%$ CI $[-.05, .41], t(69) = 1.61, p = .113$.

### 3.2. Sex difference

A GLM using a quasibinomial distribution was conducted with gaze proportion to the contrapposto stimuli as the dependent variable and sex as a fixed effect. The test revealed a significant intercept, $\beta = -0.237, SE = 0.070, t(558) = -3.375, p < .001$, and no significant fixed effect of sex, $\beta = -0.083, SE = 0.099, t(558) = 0.839, p = .402$. An ANOVA comparing model fits with an intercept only model revealed no significant difference ($\chi^2(1) = -0.249, p = .401$) suggesting there was no difference in gaze proportion to the contrapposto stimuli between sexes (see Figure 4).

### 3.3. Experimental setting and visual correction

In order to determine if there were differences between subjects that participated using desktops ($n = 54$) or laptops ($n = 17$) or between participants with different types of visual correction (contact lenses, $n = 10$; glasses, $n = 23$; neither, $n = 38$) additional GLMs were conducted using quasibinomial distributions with gaze proportion to the contrapposto stimuli as the dependent variable. No significant effects were returned ($ps > .20$) except for the intercept in the model for experimental setting, $\beta = -0.249, SE = 0.10, t(566) = -2.46, p = .0144$. These models were compared using ANOVA comparisons with their intercept only models revealing no significant differences, suggesting they were not critical predictors (Experiment setting, $\chi^2(1) = -0.155, p = .502$; visual correction, $\chi^2(1) = -0.124, p = .836$). See Supplementary Figures 2 and 3.

### 4. Discussion

The current study investigated the effect of contrapposto posture on visual attention using a preferential looking design with online gaze tracking. We tested whether contrapposto, which is shown to elevate women’s bodily attractiveness, attracts greater visual priority when competing with a standing body pose. We found that individuals looked at the contrapposto pose to a greater degree compared to a standing posture. This extends a previous study in which it was shown that individuals attend more to the curvier edges of women bodies in a contrapposto posture (Pazhoohi, Macedo, et al., 2020).

Importantly however, contrapposto poses appeared no more likely to be attended to first. The absence of an overt shift reflecting initial preference to the contrapposto stimuli suggests that the WHR exaggeration associated with a contrapposto pose may not lead to bottom-up (stimulus-driven) differences in visual attention but rather a more deliberate top-down volitional commitment of attention. In other words, the lack of a visual preference in the initial attentional shift suggests that any differences

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**Figure 2.** Gaze proportion by pose. Data represents the participants’ means across trials and error bars represent the standard error of the mean.
in visual saliency between the stimuli was not sufficient to impact initial looking behaviour. The visual preference to contrapposto stimuli over the extended time frame suggests that its preference is derived primarily from higher-level cognitive processes implicating voluntarily attentional control. This could be reflective of previously reported findings of the gaze cascade effect – that in a two-alternative forced-choice task, gaze is initially distributed evenly on both the stimuli and gradually gaze preference shifts towards the preferred stimulus (Shimojo et al., 2003). In line with a gaze cascade effect, we did not find an effect for eye movements in the beginning, yet an effect was found across the entire presentation duration, suggesting a later shift toward the contrapposto poses as the preferred stimuli.

In addition to our main research question, we sought to investigate if sociosexuality was associated with a visual bias towards contrapposto poses. Previous research has demonstrated that individuals with more unrestricted sociosexuality tendencies have visual biases for more attractive faces and bodies (Duncan et al., 2007; Maner, Gailliot, et al., 2007, Maner, Gailliot, Rouby, et al., 2007). In light of our finding that an attentional commitment to contrapposto postures is a volitional process, it follows that more unrestricted individuals may demonstrate a stronger bias for contrapposto postures. The present data did not support this prediction. We found that more unrestricted individuals were more likely to have more recorded gaze points on the contrapposto stimuli however this difference was not significant. We also found sex modulates visual attention to contrapposto stimuli, with men scoring higher than
women on SOI, and accordingly, looking more frequently at the contrapposto pose than women. However, again this was not a statistically significant result. The present findings may have been limited by a lack of power to make conclusions about the role of individual differences in gaze behaviour towards contrapposto or standing poses suggesting the need for future work.

In sum, the results of the present investigation indicate that there is a clear gaze preference for contrapposto poses compared to standing poses, and that there potentially is an individualized component to this preferential bias. Specifically, attention to contrapposto poses reflects volitional (top-down) prolonged preferences rather than reflexive (bottom-up) selection.

4.1. Future directions and conclusion

A recent study has tested the effect of contrapposto in classic male statues on perception and has found that a reduced contrapposto pose is considered more attractive and masculine (Pazhoohi et al., 2022); this is the opposite to what is recorded for the female contrapposto. Future research could explore gaze behaviour with regards to the male contrapposto posture. While male contrapposto models may be considered less attractive than female contrapposto models, perhaps the male models are still more attentionally captivating.

In sum, the current research has revealed that a female contrapposto pose is looked at more than an upright female posture. This suggests a top-down attentional bias with individuals committing greater visual attention to contrapposto postures. Future experiments using a variety of stimuli are also needed to establish the degree to which top-down influences drive the gaze preferences to contrapposto poses.

Ethics approval

This research was approved by the Behavioural Research Ethics Committee of the University of British Columbia and was conducted in accordance with the Declaration of Helsinki as it pertains to research with human participants. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

The datasets generated during and/or analysed during the current study are available via the public repository (doi: 10.17605/OSF.IO/WBZG5: https://osf.io/wbzg5/?view_only=).

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