The effect of body dysmorphic gazing on body representations: an eye-tracking paradigm

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Abstract

Biases in the processing of appearance-relevant stimuli have been proposed to play a role in the etiology and maintenance of body dysmorphic disorder (BDD). Gaze behaviour of individuals with BDD shows abnormalities for own and other people's face stimuli, which is expressed in an increased frequency of fixation on perceived flaws. The proposed causal effect on BDD development has yet to be investigated. The aim of the present study is to clarify whether gaze behavior has the potential to causally affect disorder development or body representation at all. To this end, the effect of gaze behaviour on the assessment of the attractiveness of one's own face and other people's faces is investigated in a non-clinical sample within an experimental psychopathological approach. In 2 experiments, own and other people's facial photos were to be viewed by N = 44 (Exp. 1) and N = 36 (Exp. 2) participants for several minutes with BDD-typical gaze behaviour or freely. Importantly, eye-tracking was used to monitor and maintain the respective gaze behaviour by interrupting stimulus presentation as soon as the gaze behaviour no longer corresponded to the current strategy (e.g., focus on unattractive area). Forced viewing of unattractive areas led to a decrease in attractiveness judgements in both experiments (Exp. 1: d = -.23, [-0.42, -0.03]; Exp. 2: d = -.35 [-0.67, -0.03]). Free gaze was characterized by a positive processing bias on attractive facial areas (Exp. 1: d = 2.06, [1.13, 2.83]; Exp. 2: d = 1.40, [0.72, 2.08]). The results support the assumption that gaze behaviour directly affects the formation and alteration of body representations and therefore may serve as potential causal risk factor for the development of distorted body representation and eventually clinical conditions like BDD.

Keywords:

Body representation; body dysmorphic disorder; gaze behavior; experimental psychopathology; processing bias; attention bias

Highlights:

- Eye-tracking was used to manipulate (vs. assess) body dysmorphic gaze behavior at faces.
- A body dysmorphic gaze strategy negatively affects body representation.
- Non-clinical individuals show a natural, protective positive processing bias.
- Increasing a positive processing bias may be important for treatment.

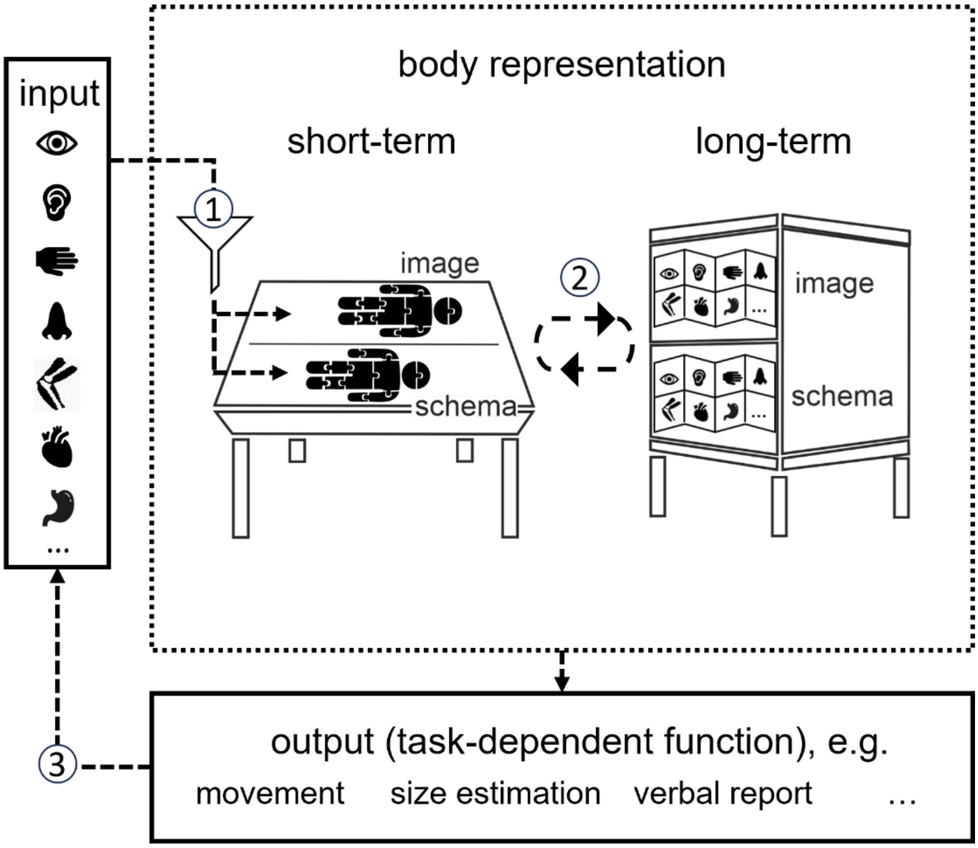
1. Introduction

The way the own body is perceived and mentally represented can have a profound impact on mental health and well-being (e.g., Gadsby, 2017; Keizer & Engel, 2022; Möllmann, Heinrichs, et al., 2024). Individuals with body dysmorphic disorder (BDD), for example, suffer from a persistent preoccupation with one or more perceived flaws in physical appearance that are either unnoticeable or only slightly noticeable to others (American Psychiatric Association, 2013). The most common areas of concern are specific facial features, especially the nose, and body features such as skin or hair. These preoccupations can take up a considerable part of everyday life and are often accompanied by excessive behaviours such as mirror gazing, grooming, camouflaging, skin-picking, reassurance seeking, and the application of cosmetic procedures (Phillips, 2005). The key features of BDD point towards the presence of distorted body representations, such as high levels of body dissatisfaction (i.e. cognitive-affective body image) and a distorted perceptual body image (for a categorization of different types of body representations including the distinction of body image and body schema see Möllmann, Heinrichs, et al., 2024). Evaluating aspect(s) of the own appearance as unattractive or even ugly and hideous can lead to severe impaired psychosocial functioning in individuals with BDD as well as low self-esteem, shame, delusionality, and co-occurring depression, anxiety and suicidality (Fang & Wilhelm, 2015). Prevalence estimates of BDD are around 2% in community samples of adults and adolescents and the disorder often persists for many years if left untreated (Veale et al., 2016). Both the severity and persistence of the disorder indicate that distortions in body representations are a significant health problem and threat to psychological well-being.

Despite the severity of the disorder, research into BDD tends to be underrepresented compared to other disorders. To further the research, one of the key questions to address is how distorted body representations are developed and maintained in BDD (Möllmann, Heinrichs, et al., 2024). Cognitive-behavioral models assume that processing biases are an important component in answering this question (Fang & Wilhelm, 2015; Veale, 2004). Examples of such processing biases, according to the model by Fang and Wilhelm (2015), are that individuals with BDD tend to react to common negative thoughts about their appearance in a biased way by selectively attending (i.e., attention bias) to certain features (e.g., Grocholewski et al., 2012; Kollei et al., 2017) and interpreting (i.e., interpretation bias) their appearance in a maladaptive way (e.g., Dietel et al., 2021). Beside attention and interpretation biases, BDD is associated with further anomalies in processing a range of visual stimuli both related and unrelated to appearance (Beilharz et al., 2017), like differences in holistic processing (e.g., Feusner et al., 2007), long-term memory (e.g., Möllmann, Peters, et al., 2024), emotional face processing (e.g., Borgers et al., 2022), and emotion recognition (e.g., Buhlmann et al., 2004).

However, despite the growing number of observed processing errors, their potential role in the development and maintenance of BDD has thus far been empirically underexplored. We have recently proposed a process model suggesting different pathways of information processing for body-related stimuli, which are involved in the formation, maintenance, or modification of distorted body representations (Möllmann, Heinrichs, et al., 2024). According to the process model, the formation of distorted body representations is primarily driven by distorted or absent sensory input affecting dynamic short-term body representations, which refer to representations of the current state of one's own body (pathway 1 in Figure 1). The maintenance of distorted body representations, on the other hand, is primarily driven by two additional pathways. Once established, distortions are imported from long-term memory and thus affect how the body is dynamically represented, as information from long-term memory is typically combined with actual sensory input in working memory (pathway 2 in Figure 1). Additionally, outputs resulting from distorted body representations (e.g., camouflaging in BDD or mirror gazing) create newly distorted input that may further stabilize the distorted representations (pathway 3 in Figure 1).

Figure 1. *Process model*



Note. The process model depicts the dynamics during the information processing of body-related stimuli. Accordingly, a short-term representation emerges from (1) weighted sensory information about the body as it currently is from different sensory sources and (2) stable information stored in long-term representations about the body as it usually is. Short- and long-term representations are combined in the service of functions (e.g., movement, size-estimation, verbal report) which might lead to (3) behavior-induced modifications of sensory input. Source: Möllmann, Heinrichs and Herwig (2024).

According to the process model, the way in which information is sampled thus plays a crucial role in the formation, maintenance, and potential modification of distorted body representations underlying BDD. It is therefore plausible that certain behaviors, which influence information processing and are typical for individuals with BDD, could play a causal role in the development and maintenance of the disorder. This study aims to place particular emphasis on mirror gazing as one most prominent example of such behaviors. Mirror gazing occurs in about 80% of individuals with BDD. On a phenomenological level, mirror gazing in BDD is well understood. For example, individuals with BDD engaging in mirror gazing report around 15 short gazing sessions of about 5 min and at least one longer gazing sessions per day of up to 170 min (Veale & Riley, 2001). These sessions tend to increase negative emotions, distress and self-focused attention (Kollei & Martin, 2014; Windheim et al., 2011). Moreover, mirror gazing can also increase dissociation in non-clinical individuals (Möllmann et al., 2020). However, regarding proposed mechanisms related to durations and specific gaze behavior during mirror gazing, the evidence is more complex. The potential effects of gazing durations on body representations (e.g., satisfaction with appearance or perceived attractiveness with the own face or facial features) have been less studied and the available evidence is mixed. For example, Möllmann and colleagues (2019) found lower attractiveness ratings for unfamiliar faces after 10 min gazing, whereas gazing on own or unfamiliar faces up to 5 min did not affect attractiveness ratings in a non-clinical sample (Möllmann et al., 2020). Another study compared two groups of non-clinical participants either under the instruction to focus on disliked parts of their face for 5 min on a near mirror (high self-focused attention) or to look into a far mirror for 5 min without specific gazing instructions (low self-focused attention) (Barnier & Collison, 2019). The high self-focused attention group showed decreased satisfaction with appearance, perceived attractiveness, and self-esteem among other variables. In contrast, Mulkens and Jansen (2009) found unchanged attractiveness ratings after 3.5 min mirror gazing and even increased ratings after 3.5 min gazing at an unfamiliar face. While these differences might be due to varying instructions to either focus on the nose throughout the gazing session (Möllmann et al., 2019, 2020), disliked parts of the face (Barnier & Collison, 2019) or to look freely (i.e. no instruction were given on how and where to look, Mulkens & Jansen, 2009), the interpretation of these results is complicated by the fact that eye movements, and thus possible attention biases, were not controlled for.

There are several eye-tracking studies revealing biased visual attention for certain areas of the face. Individuals with BDD show increased gazing at facial regions of the perceived defect (Greenberg et al., 2014; Grocholewski et al., 2012; Toh et al., 2017) or relatedly less gazing at most liked facial features (Kollei et al., 2017) when looking at photographs of their own face compared to mentally healthy individuals. In addition, in some studies a subgroup of individuals with BDD selectively avoided gazing at facial regions of their perceived defect (Greenberg et al., 2014; Toh et al., 2017). When viewing photographs of other people's faces, results are more mixed: individuals with BDD either gaze more at unattractive facial regions in unfamiliar faces (Greenberg et al., 2014; Grocholewski et al., 2012) or more at attractive facial regions (Kollei et al., 2017). However, all the reported eye-tracking studies investigated gaze behavior for relatively short stimulus presentations of 8-40 s. This duration is far below the typical duration of mirror gazing in BDD. Thus, it is unclear, how gaze behavior unfolds over extended periods of face observation. Moreover, across studies, eye movements have never been manipulated as a proxy for an attentional bias to investigate their potential causal effects on body representations.

To sum up, to date existing research does not provide rigorous tests to determine whether the assumed processing biases are causally linked to the development and maintenance of BDD. That is, it is often not possible to ascertain whether the observed biases are the cause or the result of distorted body representations. In the present study, processing biases are therefore for the first time experimentally induced using an eye tracker to examine their potential causal effects on body representations in a non-clinical sample. This aims to address two questions: 1) whether an induced attention bias could account for distorted body representation in a non-clinical sample, and 2) how gaze behavior unfolds over extended periods of face observation.

1.1 The present study

We conducted two eye-tracking experiments to test whether a BDD-like gaze strategy (i.e. focusing on perceived non-attractive areas) negatively affects body representation in a non-clinical sample. To mimic a BDD-like gaze strategy, participants were forced to look at the least attractive areas in facial photos of their face (Experiment 1 and 2) as well as facial photos of unfamiliar faces (Experiment 1) for an extended period of time (2.5 min in Experiment 1; 5 min in Experiment 2). Importantly, adherence to the BDD-typical strategy was ensured through continuous monitoring of gaze position on the presented faces. More precisely, the facial photo was only presented if the participants' gaze fell within predefined areas on the face, while leaving these areas led to the disappearance of the face. As a control, the same participants were asked to look freely at the faces presented or, in Experiment 2, to additionally focus on the areas of the face that were judged to be the most attractive. Potential effects on body representations were assessed after each gazing session by asking questions about the perceived attractiveness (and in Experiment 2, additionally about satisfaction) of the presented face (Experiment 1) or facial areas (Experiment 2).

2. Experiment 1

2.1 Methods

2.1.1 Participants

Prior to recruitment of participants, a power analysis using G*Power was conducted (Faul et al., 2009) to estimate the minimum sample size to detect a medium effect of the gazing manipulation (f = 0.25, power = 1-β = 95 %, α = 0.05), which was N = 43. A total of 46 individuals participated in the study. All reported normal or corrected-to-normal vision, and all were naïve with respect to the aim of the study. One participant terminated the experiment after a few trials and had to be excluded from further analysis. Another participant had to be excluded due to technical problems that resulted in experimental manipulation not functioning as expected. The final sample thus consisted of 44 participants (68% female; M_{age} = 27.05, SD_{age} = 8.41, $\text{Range}_{\text{age}}$: 18-66). This study was approved by the Ethics Committee of Bielefeld University (No. 2023-048.)

2.1.2 Stimulus materials and apparatus

Color photographs of five male and five female faces (NimStim face stimulus set; Tottenham et al., 2009) with a neutral expression served as stimuli. Moreover, for each participant a photograph of the own face with a neutral expression was taken with a digital camera in the laboratory before the experiment. A copy of each photo was overlaid with a blur filter to enable re-fixation on the instructed facial area in case of a deviation from the instructed gaze strategy (see Figure 2). For each participant, their own face and five gender matched faces were presented in vertical ellipses (12.9° × 16.1°) on a white background in a random order.

Stimuli were presented on a 17-in. display monitor (resolution of 1,024 × 768 pixels) at 60 cm distance. A video-based desk mounted eye tracker (Eye Link Portable Duo, SR Research, Ontario, Canada) with a sampling rate of 1000 Hz, a reported average fixation accuracy of 0.25°, and system latency below 2 ms, was used for recording and monitoring eye movements. The participants' head was stabilized by a chin rest, and the right eye was monitored in all participants.

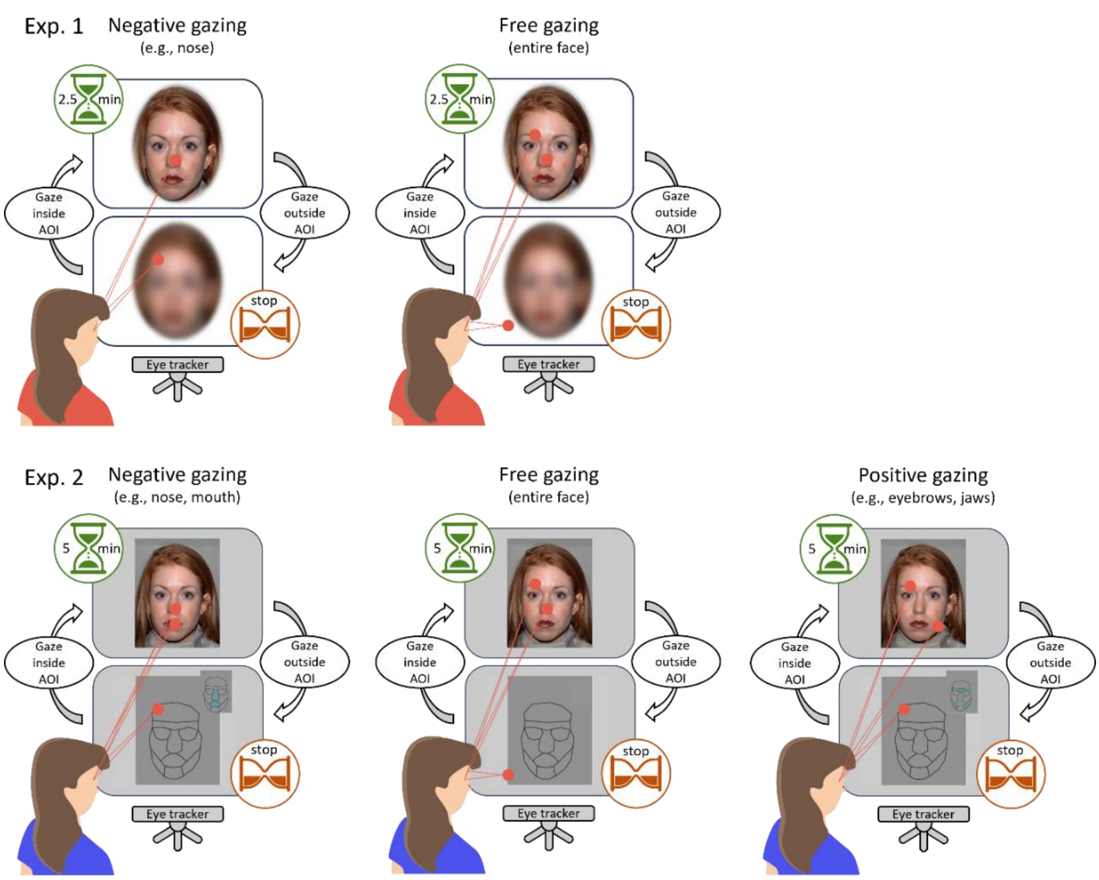
2.1.3 Design and procedure

Before the eye-tracking session, participants rated their own facial attractiveness on a 10-point Likert scale. In addition, the three facial areas, namely 'eyes,' 'nose,' and 'mouth,' were ranked based on perceived attractiveness. Subsequently, they were further rated on a 10-point Likert scale to assess their perceived attractiveness. During these assessments, the examiner processed the participant's photo identifying the coordinates of the least attractively ranked facial area. These coordinates were later utilized in the eye-tracking session to center the areas of interest (AOIs) for gaze-dependent stimulus presentation.

At the onset of the eye-tracking session, participants rated their own face and five gender-matched faces for perceived attractiveness using a visual analogue scale (VAS) ranging from 0 (not attractive) to 100 (attractive) on the monitor immediately after stimulus presentation. Photos were presented for 3 s each in a randomized order, with the attractiveness ratings during this phase serving as a baseline. The experimental manipulation of the gaze strategy occurred in two experimental conditions, which participants underwent in a counterbalanced order. In the *negative gaze condition*, participants were instructed to gaze at specific facial regions, such as 'eyes,' 'nose,' or 'mouth,' which they had identified as their least attractive facial area based on their prior evaluation in the first phase of the experiment. In the *free gaze condition*, participants were instructed to view the entire face. In both conditions, participants observed all six faces (five unfamiliar faces and their own face) for 2.5 min each in succession. Importantly, gaze behavior was continuously controlled by applying a blur effect to the faces whenever participants' gaze left the predefined AOI (ellipses of different sizes centered on the least attractive region in the negative gaze condition or rectangle of 13.3° x 16.9°

around the face in the free gaze condition). This effect greatly reduced the visibility of the depicted face, while still allowing participants to reorient their gaze to the instructed region. Moreover, leaving the predefined AOI would halt the 2.5-min timer, which resumed only upon re-entering the respective AOI. This procedure ensured that each participant had an actual dwell time of 2.5 min in the predefined areas. Ellipses of different sizes (eyes: 8.4° x 3.6°, nose: 3.6° x 5.3°, mouth: 4.8° x 3.6°), each with a center point identified individually for every photo, were selected as AOIs for the negative gaze condition. After the 2.5 min dwell time, the previously observed face was rated for perceived attractiveness on a VAS. The whole experiment lasted about 70 minutes.

Figure 2. *Experimental manipulation of the gaze strategies employed in Experiments 1 and 2*



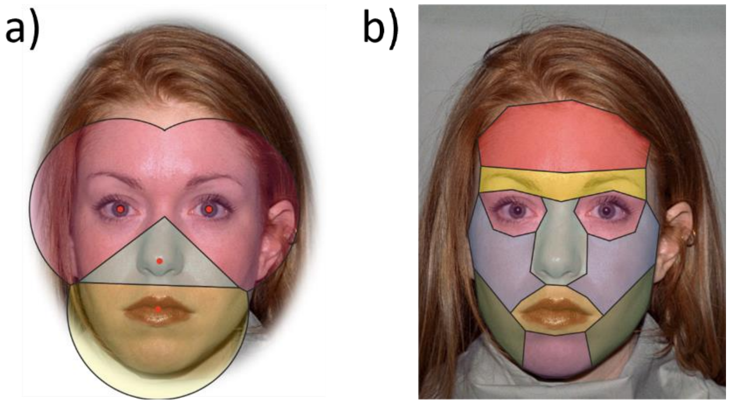
Note. Stimulus presentation was contingent on participants' gaze behavior, which was monitored by an eye-tracker: both upper rows depict the stimulus as presented during gaze behavior as instructed and both lower rows (i.e. the blurred face in Exp. 1 and the grey mask in Exp. 2) depict the stimuli as presented when participants' gaze left the instructed areas until refixation. See text for further details.

2.1.4 Data analysis

Statistical analysis and data processing were conducted using JASP (JASP Team, 2024), Microsoft Excel and EyeLink Data Viewer (SR Research Ltd., 2023). An alpha of .05 was used to determine significance. The main analysis addressing potential effects of instructed gaze on the body representation (research question 1) consisted of a 3 (condition: baseline vs. negative gaze vs. free gaze) x 2 (face: self vs. other) repeated measures ANOVA for the VAS attractiveness ratings followed by post-hoc tests using Holm correction. As suggested by Kroes and Finley (2023), ω^2 was used to report effect sizes for repeated measures ANOVA. If there were any violations of sphericity, they were corrected using the Huynh-Feldt-ε.

To analyse how uninstructed gaze behavior unfolds over extended periods of face observation (research question 2), the gaze behavior during the free gaze condition was investigated across five segments of equal length. More specifically, the proportion of trial time spent on each AOI (i.e., dwell time) was analysed in a 2 (face: self vs. other) x 3 (AOI: least attractive, middle attractive, most attractive) x 5 (time: 150 s in blocks of 30s each) repeated measures ANOVA. For this analysis, AOIs were defined with the limited-radius Voronoi tessellation method, which has been shown to be a noise-robust and highly standardized solution for face stimuli (Hessels et al., 2016, 2018). It uses the centers of the eyes, nose and mouth and ensures that any fixation that falls into one of the cells is both closest to the cell center and within a certain radius (here 4°, see Figure 3).

Figure 3. *AOIs to analyse uninstructed gaze behavior during the free gaze condition*



Note. a) In Experiment 1, AOIs around the eyes, nose, and mouth were defined with the limited-radius Voronoi tessellation method (Hessels et al., 2016, 2018). b) In Experiment 2, AOIs around the chin, cheeks, eyes, eyebrows, forehead, jaws, nose, and mouth were defined manually.

In addition to classical (frequentist) analyses, Bayesian statistical testing was implemented to quantify the evidence for the presence or absence of a given effect. Specifically, the JASP framework for repeated measures ANOVA (Bergh et al., 2019) was used to calculate inclusion Bayes factors for predictors of interest. This involved comparing models containing the effect to equivalent models without the effect. An inclusion Bayes factor serves as evidence, given the observed data, for including a particular predictor in the model.

2.2 Results

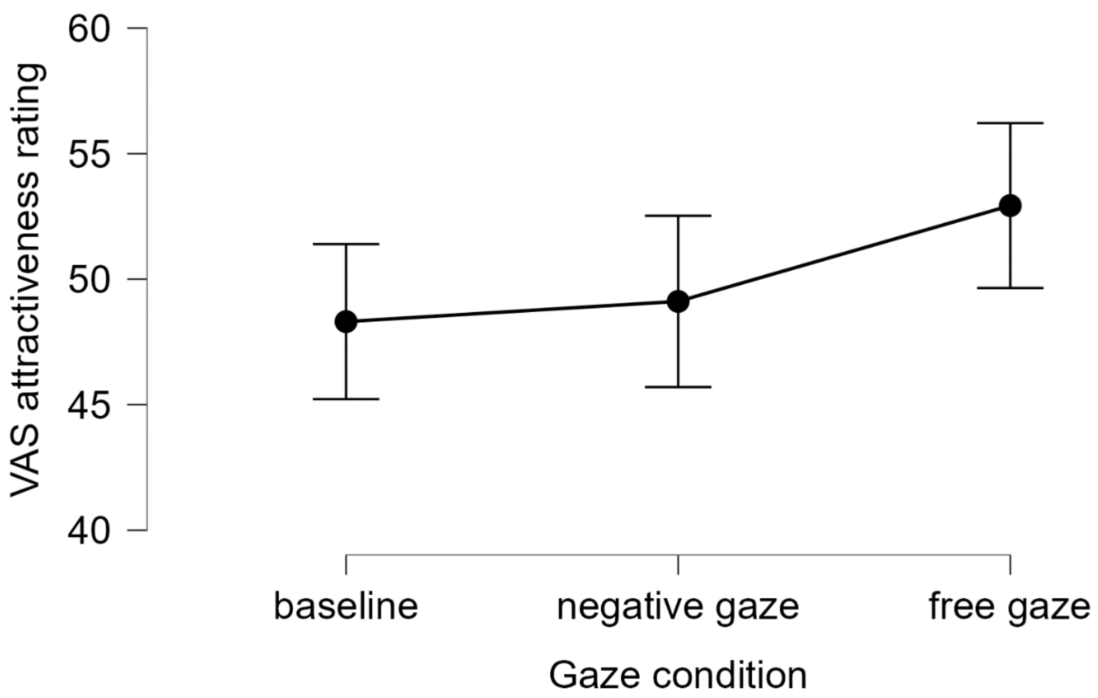
2.2.1 Assessment before the experiment

Most participants ranked their nose to be their least attractive facial area, followed by the mouth and eyes (see Table 1). The facial area ranked as the least attractive received the lowest rating for perceived attractiveness (*M*=4.93, *SD*=1.59), followed by the middle attractive (*M*=6.28, *SD*=1.50) and most attractive (*M*=7.37, *SD*=1.38) ranked areas.

2.2.2 Effects of gaze on body representation

A 3 x 2 repeated measures ANOVA was conducted on the VAS attractiveness ratings to measure the effect of gaze condition (baseline vs. negative gaze vs free gaze) and facial stimulus (self vs. other) on body representation. There was a significant main effect of condition, $F(1.82,78.39) = 7.50$, $p = .001$, $\omega^2 = .024$, $BF_{incl} = 11.03$, which is depicted in Figure 4. Post-hoc tests revealed that attractiveness ratings were lower after the negative gaze condition compared to the free gaze condition, $p_{holm} = .007$, $d = -.23$, 95% CI [-0.42, -0.03], $BF_{10,\,U} = 14.29$. Moreover, attractiveness ratings were higher after the free gaze condition compared to baseline, $p_{holm} = .001$, $d = .28$, 95% CI [-0.48, -0.08], $BF_{10,\,U} = 49.59$. There was neither a significant main effect of facial stimulus, $F(1,43) = 0.14$, $p = .712$, $\omega^2 = .000$, $BF_{incl} = 0.26$, nor a significant condition by stimulus interaction, $F(2,86) = 1.34$, $p = .254$, $\omega^2 = .001$, $BF_{incl} = 0.15$.

Figure 4. *Effect of gaze condition on attractiveness ratings in Experiment 1*



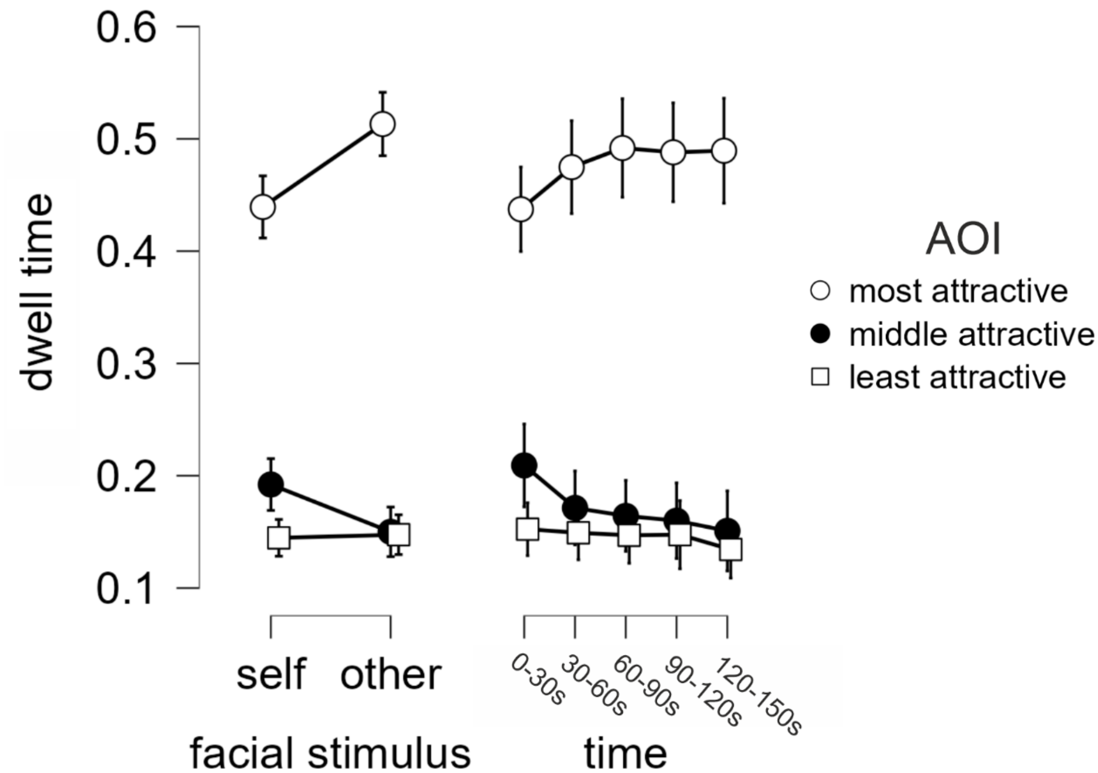
Note. Error bars indicate 95% confidence intervals.

2.2.3 Gaze behavior during the free gaze condition

During the free gaze condition, participants' uninstructed gaze behavior was investigated by analyzing the proportion of time spent at the different AOIs, ranked by their attractiveness. More precisely, a 2 x 3 x 5 repeated measures ANOVA was conducted to measure the effect of facial stimulus (self vs. other), AOI (least attractive, middle attractive, most attractive), and presentation time (5 blocks of 30s each). There were significant main effects of facial stimulus, $F(1,43) = 8.07$, $p =$

.007, ω^2 =.035, BF_{incl} = 1971.71 as well as AOI, $F(1.56,66.92) = 53.63$, $p < .001$, ω^2 =.537, $BF_{incl} > 10000$ which were qualified by a significant facial stimulus x AOI interaction, $F(1.71,73.65) = 14.88$, $p < .001$, ω^2 =.188, BF_{incl} = 6375.16, depicted in Figure 5. Post-hoc tests showed that most attractive areas were fixated longer than middle, $p_{holm} < .001$, d = 1.91, 95% CI [1.17, 2.64], $BF_{10,U} > 10000$, or least attractive areas, $p_{holm} < .001$, d = 2.06, 95% CI [1.13, 2.83], $BF_{10,U} > 10000$. In addition, participants spent more time on their most attractive AOI on other faces than on their own face, while the opposite was true for their middle attractive AOI. Finally, the ANOVA revealed a significant AOI x time interaction, $F(6.15,264.58) = 5.27$, $p < .001$, ω^2 =.071, BF_{incl} = 30.76, which is also depicted in Figure 5. As can be seen, the participants spent increasingly more time at the most attractive AOI and increasingly less time at the middle attractive AOI over the course of the 2.5-minute presentation time.

Figure 5. *Proportion of time spent at the different AOIs during the free gaze condition in Exp. 1*



Note. Error bars indicate 95% confidence intervals.

2.3 Discussion

Experiment 1 was set out to investigate whether a BDD-like gaze strategy negatively affects body representation in a non-clinical sample. The main result shows that forcing participants to gaze for 2.5 minutes at the least attractive facial area leads to a decrease in the perceived attractiveness of the presented faces compared to a free gaze instruction. This applies regardless of whether the face is one's own or an unfamiliar face.

It must be noted that, however, the BDD-typical gaze strategy did not lead to a decrease in attractiveness ratings compared to before the experiment (baseline). Instead, increased attractiveness ratings were observed after the free gaze strategy, in which participants looked freely at the faces, compared to baseline. For this pattern, two things could be responsible. 1) The majority of gaze time in the free gaze strategy was focused on the most positively rated areas of the face, which could have led to an additional enhancement of perceived attractiveness ratings. 2) Presenting a blurred face upon leaving the AOIs could have contributed to an overall enhancement of attractiveness ratings. The latter is likely because blurring faces, as was done during the gaze strategies in Experiment 1 but not during baseline assessment, has been shown to directly increase the perceived attractiveness of faces (Sadr & Krowicki, 2019). To address these points, Experiment 2 thus implemented an additional positive gaze strategy as well as a new mask without blurring to re-guide participants' gaze upon leaving the AOIs.

Regarding the second research question about how uninstructed gaze behavior unfolds over extended periods of face observation, the results showed that participants spent increasingly more time on the most attractive AOI in the free gaze condition. Additionally, they spent increasingly less time on the middle attractive AOI over the course of the 2.5-minute presentation time. This observation suggests that, at least in a non-clinical sample, longer periods of free face observation are not automatically negative. Instead, it even seems that a non-clinical sample is characterized by a positive viewing bias which may increase over time. However, it must be noted that a duration of 2.5 minutes is still below the reported average duration of the frequently occurring short mirror sessions in BDD, which is around 5 minutes (Veale & Riley, 2001). To investigate natural gaze behavior during longer observations of one's own face, the duration was thus extended to 5 minutes in Experiment 2.

3. Experiment 2

Experiment 2 utilizes the eye-tracking paradigm developed in Experiment 1 with the following changes. 1) Only photos of the participants' own faces were presented. This allowed for: 2) extending the net observation time from 2.5 to 5 minutes and 3) also implementing a positive gaze strategy (in addition to the negative and free strategies). Furthermore, for methodological reasons, 4) the blurred mask was omitted, 5) a more detailed division of the face into 8 facial areas was made, and 6) satisfaction with the individual facial areas, in addition to attractiveness, was also assessed.

3.1 Methods

3.1.1 Participants

Before recruiting participants, a power analysis was conducted using G*Power to estimate the minimum sample size (f = 0.25, 1-β = 95%, α= 0.05), resulting in a required sample size of N = 36. A total of 36 individuals (72% female; M_{age} = 28.11, SD_{age} = 11.66, $\text{Range}_{\text{age}}$: 18-65) participated in Experiment 2. All reported normal or corrected-to-normal vision, and all were naïve with respect to the aim of the study.

3.1.2 Stimulus materials and apparatus

As in Experiment 1, a photo of the own face with a neutral expression was taken for each participant with a digital camera in the laboratory before the experiment. Instead of blurred facial stimuli, an individual 'mask' was created for each photo taken showing the position of the different facial areas (i.e., chin, cheeks, eyes, eyebrows, forehead, jaws, nose, and mouth) on a neutral grey background (see Figure 2). The apparatus for stimulus presentation and eye tracking in Experiment 1 and 2 was identical. Stimuli were presented on a light grey background.

3.1.3 Design and procedure

Participants made two appointments in the laboratory. In session 1, the photograph was taken and participants completed a short five-item screening questionnaire for body dysmorphic disorder (KDS-K, Brunhoeber & Maes, 2007). In addition to participants' self-report, a clinician's assessment of potential defects or flaws in appearance is required to calculate the total score. In this study, this assessment was performed by one of the authors (AM). Moreover, participants rated their current satisfaction with and perceived attractiveness of each of eight facial areas (forehead, eyebrows, eyes, nose, mouth, chin, jaw and cheeks) on a 5-point Likert scale. Subsequently, the eight facial areas were ranked based on perceived attractiveness. The two most attractive and two least attractive areas of the face were than selected as AOIs for the negative and positive gaze conditions in session 2.

At the beginning of session 2, participants once again rated their current satisfaction with and perceived attractiveness of each of eight facial areas with the ratings during this phase serving as a baseline. The experimental manipulation of the gaze strategy occurred in three experimental conditions, which participants underwent in a counterbalanced order. In the *negative gaze condition*, participants were instructed to gaze at the two facial regions, which were identified as their least attractive facial areas based on their prior evaluation in session 1. In the *positive gaze condition*, participants were instructed to gaze at their two most attractive facial regions. Finally, in the *free gaze condition*, participants were instructed to view the entire face. In all three conditions, participants observed their own face for a net time of 5 min. Importantly, gaze behavior was continuously controlled by replacing the photo of the participant's own face with an individual 'mask', thus allowing participants to reorient their gaze to the instructed region whenever their gaze left the predefined AOIs (see Figure 2). Moreover, leaving the predefined AOIs would halt the 5-min timer, which resumed only upon re-entering the respective AOI, ensuring that each participant had an actual dwell time of 5 min in the predefined areas. After each gaze condition, participants rated their current satisfaction with and perceived attractiveness of each of eight facial areas and the complete face. The eye-tracking session lasted about 40 minutes.

3.2 Results

3.2.1 Assessment before the experiment

Most participants ranked their chin to be their least attractive facial area and their eyes as their most attractive facial area (see Table 1, for further details). The ranking was by and large also reflected in the attractiveness and satisfaction ratings prior to the eye-tracking session. The screening questionnaire for body dysmorphic disorder (KDS-K, Brunhoeber, 2019; Brunhoeber & Maes, 2007) identified 10 participants exceeding the clinical cutoff (i.e., 12 points or more). Table 2 shows the sample characteristics for participants above and below the cutoff.

Table 1.

Self-assessment of one's facial areas before the experiment

	Facial Area	Rank least to most attractive, Mean (SD)	Least attractive (%)[a]	Middle attractive (%)[a]	Most attractive (%)[a]	Attractiveness, Mean (SD)	Satisfaction, Mean (SD)
Exp. 1	Nose	1.23 (0.53)	81	14	5	2.75 (1.26)[b]	-
	Mouth	1.98 (0.51)	14	74	12	3.35 (1.22)[b]	-
	Eyes	2.79 (0.51)	5	12	84	3.83 (1.17)[b]	-
Exp. 2	Chin	2.72 (1.50)	64	36	0	3.14 (1.07)	3.36 (1.10)
	Jaw	3.44 (1.71)	28	67	6	3.53 (0.94)	3.75 (1.08)
	Nose	3.67 (2.55)	44	31	25	3.33 (1.01)	3.58 (1.05)
	Forehead	4.08 (2.16)	31	58	11	3.50 (0.97)	3.86 (1.05)
	Cheeks	4.89 (1.98)	11	64	25	3.72 (0.85)	3.83 (1.03)
	Eyebrows	5.08 (2.16)	14	53	33	3.64 (0.90)	3.92 (0.97)
	Mouth	5.50 (1.96)	3	61	36	3.78 (0.99)	4.00 (1.01)
	Eyes	6.61 (1.73)	6	31	64	3.97 (0.97)	4.25 (0.84)

Note. [a] In Experiment 2, ranks 1 and 2 were grouped into the least attractive category, ranks 3 to 6 into the middle attractive category and ranks 7 and 8 into the most attractive category. [b] The attractiveness ratings from Experiment 1 were converted from a 10-point Likert scale to a 5-point Likert scale using a linear transformation to allow for comparison between the experiments.

Table 2.

Sample characteristics for participants above and below the clinical KDS-K cutoff in Experiment 2

	below KDS-K cutoff (n = 26), Mean(SD)	above KDS-K cutoff (n = 10), Mean(SD)	Group differences Test
Age	29.77 (13.25)	23.80 (3.46)	$p = .042$
Gender, female/male	19/7	7/3	$p = .853$
KDS-K	6.23 (2.98)	14.80 (1.99)	$p < .001$
Attractiveness[a]	3.61 (0.68)	3.49 (0.45)	$p = .537$
Satisfaction[a]	3.88 (0.55)	3.66 (0.63)	$p = .353$

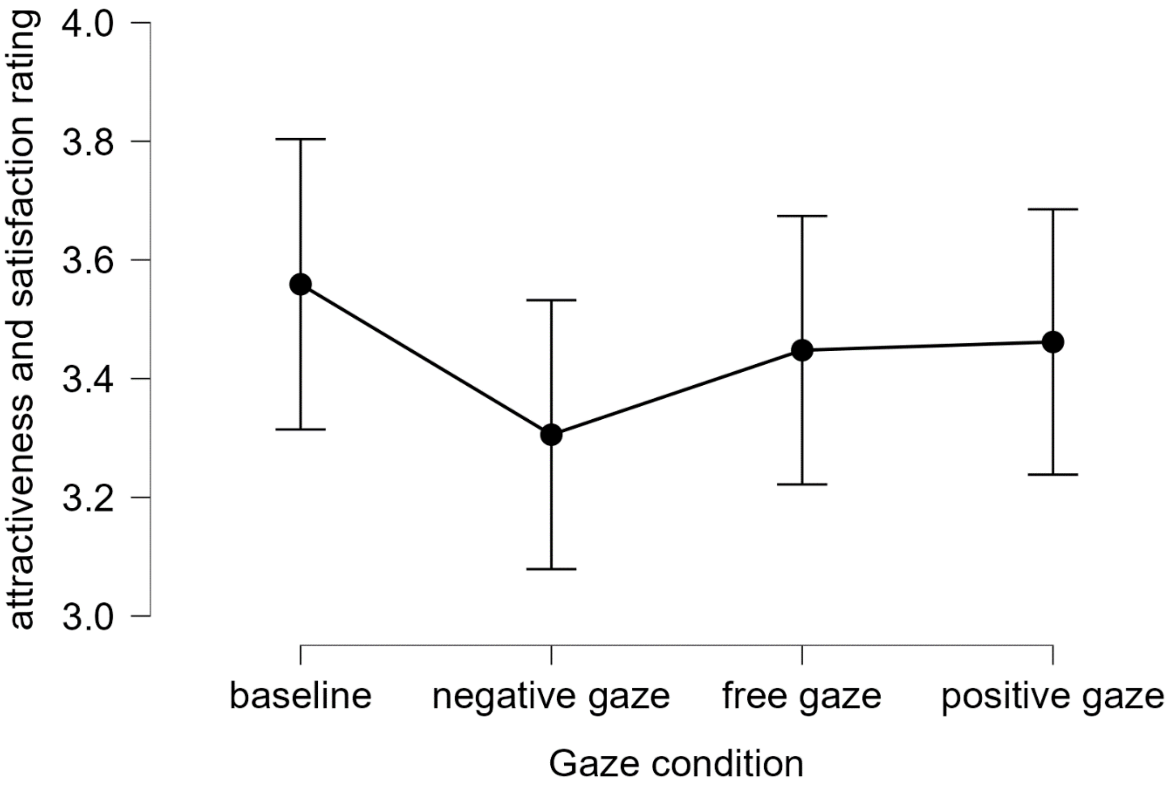
Note. [a] averaged over the facial areas. KDS-K = short screening questionnaire for body dysmorphic disorder (Brunhoeber, 2019; Brunhoeber & Maes, 2007)

3.2.2 Effects of gaze on the body representation

The attractiveness and satisfaction ratings were averaged to create a single measure, providing a more comprehensive assessment of body representation. Next, the ratings for the least (ranks 1 and 2) and most (ranks 7 and 8) attractive facial areas were calculated, as these areas were targeted in the negative and positive gaze conditions, respectively. This allowed us to analyze possible influences of the gaze condition (baseline vs. negative gaze vs. free gaze vs. positive gaze) on the different facial areas (least attractive vs. most attractive) using a 4 x 2 repeated measures ANOVA. The analysis revealed significant main effects of gaze condition, $F(1.93,67.47) = 3.34$, $p = .043$, $\omega^2 = .019$, $BF_{\text{incl}} = 1.69$, as well as facial area, $F(1,35) = 79.92$, $p < .001$, $\omega^2 = .502$, $BF_{\text{incl}} > 10000$. The main effect of condition is depicted in Figure 6. Post-hoc tests showed that participants' ratings were lower after the negative gaze condition compared to the baseline condition, $p_{\text{holm}} = .013$, $d = -.35$, 95% CI [-0.67, -0.03], $BF_{10,\,\text{U}} = 4.12$. There was no significant difference between the negative gaze condition compared to the free gaze condition according to frequentist statistics, though evidence in favour of the alternative hypothesis was moderate based on Bayesian statistics, $p_{\text{holm}} = .324$, $d = -.20$, 95% CI [-0.51, 0.11], $BF_{10,\,\text{U}} = 3.58$. Unsurprisingly, the main effect of facial area reflected lower ratings for the least attractive areas ($M = 2.81$, $SD = 0.84$) compared to the most attractive areas ($M = 4.08$, $SD = 0.58$). There was no significant gaze condition x facial area interaction, $F(3,105) = 0.58$, $p = .632$, $\omega^2 = .000$, $BF_{\text{incl}} = 0.15$.

In an exploratory analysis, it was also examined whether group affiliation (below vs. above the clinical cutoff) had a potential influence on the pattern of results. For this purpose, group was included in the ANOVA as an additional between-subjects factor. However, neither the main effect nor the interactions with group were significant (all ps > .165, ω^2s ≤ .007, $BFs_{\text{incl}} < 0.47$).

Figure 6. *Effect of gaze condition on the combined attractiveness and satisfaction ratings in Experiment 2*



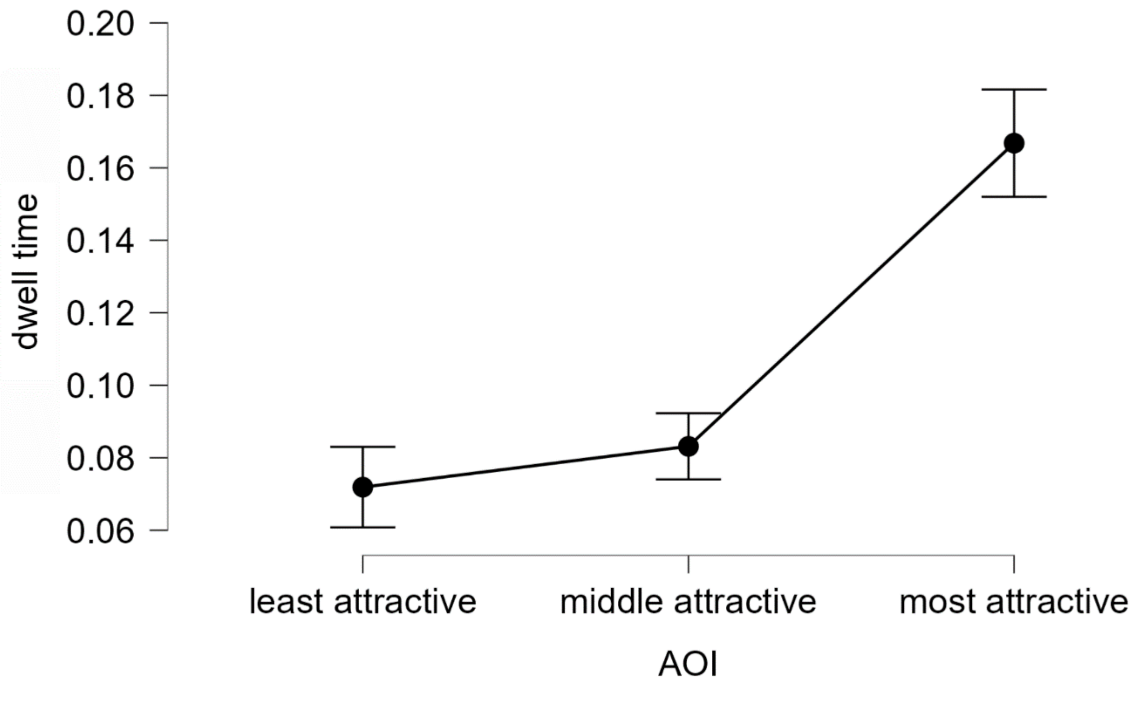
Note. Error bars indicate 95% confidence intervals.

3.2.3 Gaze behavior during the free gaze condition

Participants' uninstructed gaze behavior during the free gaze condition was examined by analyzing the proportion of time they spent on different AOIs. An initial inspection of the dwell time data revealed that one participant's total dwell time was below two standard deviations from the mean, likely indicating technical difficulties in fixation detection during the free gaze condition. This participant was thus excluded from the following analysis. AOIs were grouped based on their attractiveness ranking into three categories: least attractive (ranks 1 and 2), middle attractive (ranks 3 to 6), and most attractive (ranks 7 and 8). As in Experiment 1, the net presentation time was divided into five sections of equal length (here one minute each) to investigate possible changes over time. This resulted in a 3 x 5 repeated measures ANOVA analyzing the effect of AOI and presentation time. There were significant main effects of AOI, $F(1.71,58.00) = 23.83$, $p < .001$, $\omega^2 = .367$, $BF_{\text{incl}} >$ 10000, as well as presentation time, $F(3.35,113.85) = 7.69$, $p < .001$, $\omega^2 = .056$, $BF_{\text{incl}} = 0.07$. As can be seen in Figure 7 and as revealed by post-hoc tests, participants spent more time on their most attractive AOI than on their middle, $p_{\text{holm}} < .001$, $d = 1.23$, 95% CI [0.58, 1.89], $BF_{10,\text{U}} > 10000$, and least, $p_{\text{holm}} = .001$, $d = 1.40$, 95% CI [0.72, 2.08], $BF_{10,\text{U}} > 10000$, attractive AOIs. In addition, participants spent less time on the AOIs during the fifth minute than during the first, second, and third minutes. There was no significant AOI x time interaction, $F(5.31,180.47) = 0.92$, $p = .473$, $\omega^2 = .000$, $BF_{\text{incl}} = 0.02$.

Potential influences of group affiliation (below vs. above the clinical cutoff) were once again tested by including group in the ANOVA as an additional between-subjects factor. However, there were neither a significant main effect of group nor interactions with group (all ps ≥ .406, ω^2s ≤ .000, BFs_{incl} < 0.07).

Figure 7. *Mean proportion of time spent at the different AOI categories during the free gaze condition in Experiment 2*



Note. In Experiment 2, ranks 1 and 2 were grouped into the least attractive category, ranks 3 to 6 into the middle attractive category and ranks 7 and 8 into the most attractive category. Depicted are the mean proportion of dwell times (i.e., total dwell times in each category can be computed by multiplying the mean dwell times by the number of AOIs in each category). Error bars indicate 95% confidence intervals.

3.3 Discussion

Experiment 2 was designed to investigate whether the negative effect of a BDD-typical gaze strategy observed in Experiment 1 can also be replicated during longer observations of one's own face. The results confirm the negative impact of a BDD-typical gaze strategy on body representation: forcing participants to gaze for 5 minutes at their least attractive facial areas decreased perceived attractiveness of and satisfaction with their facial areas. However, unlike in Experiment 1, this effect was observed in comparison to the baseline condition instead of the free gaze condition. This is probably due to methodological choices and suggests that the new masks used in Experiment 2 did not lead to a general increase in perceived attractiveness, as the blurred faces in Experiment 1 likely did (Sadr & Krowicki, 2019). Thus, the use of the new masks seems to provide a more accurate view of the possible influences of a BDD-typical gaze strategy on body representation. It should be noted that although the difference between the negative gaze condition and the free gaze condition was not significant according to frequentist statistics this time, the effect was comparable in direction and magnitude (d = -.20) to Experiment 1 (d = -.23) and Bayesian statistics revealed moderate evidence in favour of the alternative hypothesis.

Interestingly, forcing participants to gaze at their non-attractive facial areas diminished the perceived attractiveness of and satisfaction with both their perceived non-attractive and attractive facial areas. This suggests that a negative gaze strategy can have a generalization effect on body representations, also spilling over to facial areas that are not directly observed.

Regarding the positive gaze condition, Experiment 2 provides no evidence of an additional positive effect on body representation beyond the free gaze condition. One reason could be that the positive strategy may already have been an established gaze pattern in the present sample. Consistently, participants spent less time on their least and middle attractive AOIs than on their most attractive

AOI during the free gaze condition, indicating a positive viewing bias similar to Experiment 1. However, the AOI x time interaction observed in Experiment 1 was not replicated with the extension of the observation time to 5 minutes. This suggests that the positive viewing bias in a non-clinical sample may only intensify during the first minute and then remain on a stable level during longer observation times.

An exploratory analysis of the results based on BDD-like concerns, as assessed by the short BDD screening questionnaire, yielded no significant findings. However, this result should be interpreted cautiously, as the groups above and below the cut-off value also did not differ in terms of attractiveness and satisfaction with their facial areas during the baseline assessment. Future studies with sub- and clinical samples are therefore urgently needed to identify possible group differences in gaze behavior during longer face observations.

4. General Discussion

The current study used an experimental psychopathology approach to investigate the influence of BDD-like gaze behavior on body representations in a non-clinical sample. Across two experiments, we compared different gaze strategies, namely free gaze and an eye-tracker led induction of either a negative or positive processing bias, and consistently found that the way individuals look at their own and unfamiliar faces has a direct impact on their perceived attractiveness of these faces. Specifically, forcing individuals to adopt a BDD-like gaze strategy by focusing at their perceived most unattractive facial areas for several minutes (negative gaze) diminished the perceived attractiveness and satisfaction with their own face. The same was also true for gazing at unfamiliar faces. In contrast, the natural gaze behavior of the non-clinical sample was characterized by an increased focus on the most attractive facial areas. This uninstructed positive processing bias, as well as the forced viewing of attractive areas (positive gaze) implemented in Experiment 2, protected against a deterioration in body representation despite extended face observation times of up to 5 minutes.

In general, these results support the model assumption that distortions in body representations, as typical for various mental disorders, can be caused by atypical processing of sensory input

(Möllmann, Heinrichs, et al., 2024). Within our process model, this effect can be understood as follows: Gaze behavior occupies both the starting and ending points in the cycle of body-related information processing. At the start (i.e., input, see Figure 1 pathway 1), gaze behavior provides the visual information that feeds into current body representations. At the end (i.e., output, see Figure 1 pathway 3), gaze behavior relies on these stored body representations to continue sampling body-related information. Attention biases manifest directly in gaze behavior as an excessive prioritization of either unattractive facial areas at the expense of attractive ones (negative attention bias) or vice versa (positive attention bias). As the results of this study demonstrate, gaze behavior has direct consequences for body representations, which are used to assess the perceived attractiveness and satisfaction with one's face (i.e., perceptual and cognitive-affective body image, Möllmann, Heinrichs, et al., 2024).

Importantly, support for this hypothesized causal direction was enabled by adopting an experimental psychopathology approach and directly manipulating processing biases of facial stimuli, which have been reported in previous studies on gazing in BDD (Greenberg et al., 2014; Grocholewski et al., 2012; Toh et al., 2017). In these previous studies, eye-tracking has been used to *assess* the constructs of interest, such as gaze behavior or potential attention biases, and to then compare these aspects between individuals with and without BDD. Extending on these findings, we used eye-tracking as a method of *experimental manipulation* to test whether the reported attention bias patterns could serve as a causal risk factor for the development of distorted body representations and eventually mental disorders like BDD.

Our results are consistent with other findings from experimental psychopathology research in the context of eating disorders. For example, body satisfaction also decreased in non-clinical female students when a temporary attentional bias towards self-defined unattractive body parts outside the face was induced (Smeets, Jansen, et al., 2011; Smeets, Tiggemann, et al., 2011). Moreover, similar to the present results of Experiment 2, participants in these studies did not show an increase in body and weight satisfaction after a positive bias induction. These patterns indicate that, without the presence of a clinical condition like BDD or an eating disorder, a positive bias is common in viewing body- and face-related information and might represent the natural "default" gaze pattern. This form of positive bias might serve as a protective factor supporting mental health.

The findings of our study have three main clinical implications regarding processing biases for prevention and treatment contexts. First, consolidating or increasing a positive processing bias, especially regarding own face/body stimuli, appears to be an important goal for prevention of distorted body representations and related clinical conditions. We and other researchers have shown that a positive bias is present in non-clinical individuals during free gaze but is lacking in individuals with versus without certain mental disorders, even beyond conditions related to body representations and across different biases, including attention, interpretation or memory biases (e.g. for eating disorders in adolescents: Bauer et al., 2017; for depression: Everaert et al., 2017; for BDD: Kollei et al., 2017). Second, our findings support that most mirror exposure tasks for treating BDD or eating disorders do (and should) not follow a habituation approach. This rationale would further strengthen the already existing negative processing bias towards bodily regions perceived as unattractive, which in turn would perpetuate the negative appearance evaluation. Third, our findings support the importance of existing treatment modules targeting negative processing biases and imply that they may be extended regarding the lack of positive bias. For example, in the module perceptual retraining in the treatment of BDD (Wilhelm et al., 2013), patients are instructed to look at their own body in a mirror more holistically (i.e. equal amount of time for each region) and describe it in a neutral way. Thereby, the retraining effectively targets negative biases, namely reducing overfocusing on perceived defects (i.e. a negative processing bias) and negative or self-scrutinizing descriptions of the own body. Future research may investigate, whether additionally training individuals to focus more on facial or body areas which they perceive as rather attractive helps to establish a protective positive bias.

The following limitations may be considered interpreting our study results. First, demographic participant characteristics, such as age and gender, may limit generalizability of the results with a mean age around 30 years and around two-third of the participants identifying as female. However, especially regarding face gazing and BDD symptoms, there is no evidence that age and gender substantially influence the investigated processes. Second, regarding the exploratory analyses including BDD symptom status, future research may include another BDD symptom measure, as the groups based on the current measure did not differ regarding their mean attractiveness ratings of their own appearance.

4.1 Conclusions

In the present study, we showed that 2.5 to 5 minutes of face observation with an eye-tracking led BDD-like negative gaze strategy was sufficient to negatively impact body representations in a non-clinical sample. Although future research should extend to (sub)clinical samples, it appears highly likely that such negative effects could accumulate due to excessive mirror-gazing sessions that are reported for individuals with BDD (cf. Veale & Riley, 2001). Gazing on unattractive areas of the face for extended periods may be a potential risk factor for the development and maintenance of BDD. Further, during free gaze a natural positive processing bias was present, which might serve as a protective factor for the development of distortions in body representation or related clinical conditions and thus be an important target for prevention. The results are supporting evidence for cognitive-behavioral models of BDD and suggest that treatment modules addressing negative processing biases, such as perceptual retraining, may be extended towards establishing a protective positive bias as well.

Author Contributions CRediT Roles:

AH: Conceptualization, Data acquisition and curation, Formal analysis, Visualization, Writing – review and editing, Writing – original draft

MG: Data acquisition and curation, Formal analysis, Writing – review and editing

NH: Conceptualization, Resources, Supervision, Writing – review and editing

AM: Conceptualization, Writing – original draft, Writing – review and editing

Data Statement:

The dataset generated and analyzed during the current study is available through

https://osf.io/mu28j/

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