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Adaptation effects to attractiveness of face photographs and art portraits are domain-specific

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Abstract. We studied the neural coding of facial attractiveness by investigating effects of adaptation to attractive and unattractive human faces on the perceived attractiveness of veridical human face pictures (Experiment 1) and art portraits (Experiment 2). Experiment 1 revealed a clear pattern of contrastive aftereffects. Relative to a pre-adaptation baseline, the perceived attractiveness of faces was increased after adaptation to unattractive faces, and was decreased after adaptation to attractive faces. Experiment 2 revealed similar aftereffects when art portraits rather than face photographs were used as adaptors and test stimuli, suggesting that effects of adaptation to attractiveness are not restricted to facial photographs. Additionally, we found similar aftereffects in art portraits for beauty, another aesthetic feature that, unlike attractiveness, relates to the properties of the image (rather than to the face displayed). Importantly, Experiment 3 showed that aftereffects were abolished when adaptors were art portraits and face photographs were test stimuli. These results suggest that adaptation to facial attractiveness elicits aftereffects in the perception of subsequently presented faces, for both face photographs and art portraits, and that these effects do not cross image domains.

Keywords: face perception, attractiveness, adaptation, art perception, aesthetics, beauty.

1 Introduction

Amongst the many visual stimuli we regularly encounter, the human face is of particular relevance. Not only is it an important cue to the identity of familiar people, but the efficient analysis of identity-invariant information also allows for the categorization of unfamiliar faces, e.g. according to their gender, age, ethnicity, or emotional expression. In addition to these seemingly objective decisions about social categories, we also tend to instantly rate the attractiveness of a face (Cellerino, 2003). This aesthetical judgement appears to be of comparatively subjective nature. Indeed, prior research suggested that the perception of attractiveness partly depends on individual preferences within the observer (Honekopp, 2006).

However, there is also a large body of evidence showing that attractiveness ratings are remarkably consistent across observers and even cultures (Cunningham, Roberts, Barbee, Druen, & Wu, 1995; Eagly, Ashmore, Makhijani, & Longo, 1991; Feingold, 1992a, 1992b; Langlois et al., 2000; Rhodes et al., 2001a). This high consensus suggests that objective and universal factors determine the perception and judgement of facial attractiveness. An active area of research has been dedicated to investigating these factors, and statistical models have been developed to predict human ratings of

facial attractiveness effectively, by analysing shape and relation of facial features (Bronstad, Langlois, & Russell, 2008).

High correlations with attractiveness ratings suggest that symmetry along the vertical axis is generally considered a pleasant facial feature (Little, Apicella, & Marlowe, 2007; Rhodes, Carey, Byatt, & Proffitt, 1998). In addition, the averageness, or prototypicality, of a face has been found to be an important determinant to attractiveness judgements, even when keeping symmetry constant (Baudouin & Tiberghien, 2004; Langlois & Roggman, 1990; Rhodes & Tremevan, 1996; Rhodes et al., 2001a; Rubenstein, Kalakanis, & Langlois, 1999; Valentine, Darling, & Donnelly, 2004). It has been suggested that this somewhat counterintuitive relationship is driven by the fact that averageness indicates a large degree of genetic heterogeneity and might therefore serve as an indicator of health and mating quality (Rhodes et al., 2001a, 2001b). Finally, secondary sexual characteristics have been shown to be an additional factor influencing judgements of attractiveness. Specifically, feminine female faces and masculine male faces are considered more attractive than less gender dimorphic faces (Baudouin & Tiberghien, 2004; Rhodes, Hickford, & Jeffery, 2000; Russell, 2009). Again, this relationship might be driven by biological mechanisms, in this case by the sex hormones estrogen and testosterone, that might both indicate fertility and lead to distinct phenotypical characteristics such as full lips in women or a pronounced chin line in men, respectively (Jones et al., 2005). In line with this idea, female viewers have been shown to be particularly attracted to masculine features during the fertile stage of their hormonal cycle (Penton-Voak & Perrett, 2000).

Mechanisms of face perception and the perception of facial attractiveness have been explored using a large variety of experimental paradigms. Amongst others, the investigation of aftereffects induced by visual adaptation has been proved to be extremely insightful. Aftereffects have long been employed to study perceptual mechanisms on early stages of visual processing, using relatively simple stimulus properties, such as luminance, contrast (Chen, Zhou, Gong, & Liang, 2005), colour or motion (Antal et al., 2004). The term adaptation refers to changes in the neuronal response as a consequence of prolonged exposure to certain stimulus features. These neural adjustments constantly recalibrate our visual system to the stimulus features actually present in the environment. A behavioural correlate of this recalibration is the so-called aftereffect, that is, an altered perception of the respective stimulus feature as a consequence of adaptation. Prolonged exposure to downward motion, for instance, has been shown to lead to an illusionary perception of upward motion in a static image. The contrastive nature of this aftereffect provides insight into the neural coding of vertical motion, suggesting that distinct cell populations code motion in opposite directions. If prolonged stimulation of one of these populations leads to neural fatigue, the output of the opposite population dominates after stimulus offset, biasing perception away from the adapted characteristic (for a review, see Anstis, Verstraten, & Mather, 1998).

Adaptation is also of central importance for face perception. In 1999, Webster and MacLin described the face distortion aftereffect showing that adaptation to faces that were either expanded or contracted made participants classify subsequent undistorted faces as contracted or expanded, respectively. Since then, it has been revealed that adaptive recalibration also occurs in the perception of facial identity (Leopold, O'Toole, Vetter, & Blanz, 2001; Nishimura, Maurer, Jeffery, Pellicano, & Rhodes, 2008; Rhodes & Jeffery, 2006), age (Schweinberger et al., 2010), expression, gender, and ethnicity (Webster, Kaping, Mizokami, & Duhamel, 2004). These studies suggest that the perception of many, if not all, dimensions on which we categorize faces is subject to adaptive recalibration.

However, an unresolved question is whether the selective exposure to attractive or unattractive faces leads to similar contrastive aftereffects in the perception of facial attractiveness. There is some indication that attractiveness judgements of faces can be influenced by recent visual exposure. In line with findings that a large degree of averageness or prototypicality is perceived as attractive, Rhodes, Jeffery, Watson, Clifford, & Nakayama (2003) found that after adaptation to highly contracted face photographs, slightly contracted faces were not only perceived as more normal (Rhodes et al., 2003; Webster & MacLin, 1999), but were also rated as more attractive. In a later study, a similar effect on perceived attractiveness was also reported after adaptation to faces with systematic asymmetries (Rhodes, Louw, & Evangelista, 2009). On the contrary, DeBruine and colleagues weakened the averageness hypothesis, according to which attractiveness is an indicator for averageness. In their study, exposure to manipulated attractive faces did not affect attractiveness ratings and "normality" ratings of subsequent faces in the same way (DeBruine, Jones, Unger, Little, & Feinberg, 2007).

The aim of the present study was to go beyond using attractiveness judgements as means to determine the degree of adaptation-induced renormalization in the perception of facial distortions.

We more directly investigated whether adaptation to attractive versus unattractive faces (as opposed to contracted vs. expanded) also induces changes in the perception of attractiveness of subsequently presented faces. To this end, we compared how participants rated the attractiveness of faces before and after selective adaptation to either attractive or unattractive face images that naturally varied in attractiveness. In contrast to previous studies, we used a large number of veridical non-morphed face pictures that were rated as being high, intermediate, or low in attractiveness. Faces of intermediate attractiveness served as test stimuli, while faces of high and low attractiveness were used as attractive and unattractive adaptors, respectively. Consequently, the presented adaptation study examines changes in the perception of actual naturalistic faces rather than ambiguous face morphs.

We present a series of three experiments all of which employed a face adaptation paradigm to investigate the degree to which face attractiveness judgements are influenced by prior exposure. In Experiment 1, we used naturalistic face photographs as adaptor and test stimuli. Experiment 2 examined whether the results of the first experiment extend to the perceived attractiveness and beauty of art portraits of faces. Finally, Experiment 3 studied the possible domain-specificity of face attractiveness aftereffects using art portraits as adaptors and face photographs as test images.

2 Experiment 1: Adaptation to attractiveness of face photographs

2.1 Experiment 1A: Adaptation to facial attractiveness on face photographs

2.1.1 Methods

2.1.1.1 Participants.

Thirty-five participants (18–26 years, M = 22.9 years, 10 male) contributed data. All participants were students or graduates of medical or life sciences. They all reported normal or corrected-to-normal vision and gave their written consent prior to the experiment. The study was conducted in accordance with the ethical guidelines of the Declaration of Helsinki and was approved by the ethics committee of Jena University Hospital.

2.1.1.2 Stimuli.

The stimuli consisted of greyscale digital photographs of 60 men and 60 women aged between 19 and 55 years derived from the FACES Database of the Max Planck Institute for Human Development (Ebner, Riediger, & Lindenberger, 2010). The models were photographed in frontal view with neutral facial expression and no specific features, such as make-up, facial hair, jewellery, or glasses. Each image was resized to 1024 × 1024 pixels. Faces were fitted behind an oval mask hiding the outer contours of the faces, the hair, and the background of the photograph (Figure 1, A–C). Images were shown individually on a black screen (EIZO ColorEdge CG241W) at a viewing distance of 90 cm that was ensured by the use of a chin rest. Stimuli used as adaptation stimuli were presented at a size of 155 × 155 mm (10° × 10° of visual angle), test stimuli measured 107 × 107 mm (6° × 6° of visual angle).

2.1.1.3 Attractiveness ratings.

In order to determine the perceived attractiveness of each face, 40 participants (18–26 years, M = 21.1 years, 14 male) not taking part in the main experiments were asked to rate the faces. The scale ranged from 1 (very attractive) to 4 (very unattractive). The scale was based on the grading system at German schools and universities in which 1 is the best possible grade and 4 is the worst grade that still passes an exam. Participants were told that attractiveness was defined as the physical allurement of a face. Based on their mean attractiveness ratings, stimuli were then allocated to one of three sets (20 images with low, 80 images with intermediate, and 20 images with high attractiveness ratings, M ± SD = 3.53 ± 0.12, 2.81 ± 0.35, and 1.82 ± 0.28, respectively). In the main experiments, pictures with low and high scores on the rating scale served as attractive and unattractive adaptors, respectively, while stimuli of intermediate scores served as test stimuli.

2.1.1.4 Design.

We varied the factor Adaptation Condition (baseline, after adaptation to unattractive faces, after adaptation to attractive faces) within subjects. Although all participants completed the baseline phase first, the order of adaptation to attractive and unattractive faces was counterbalanced.

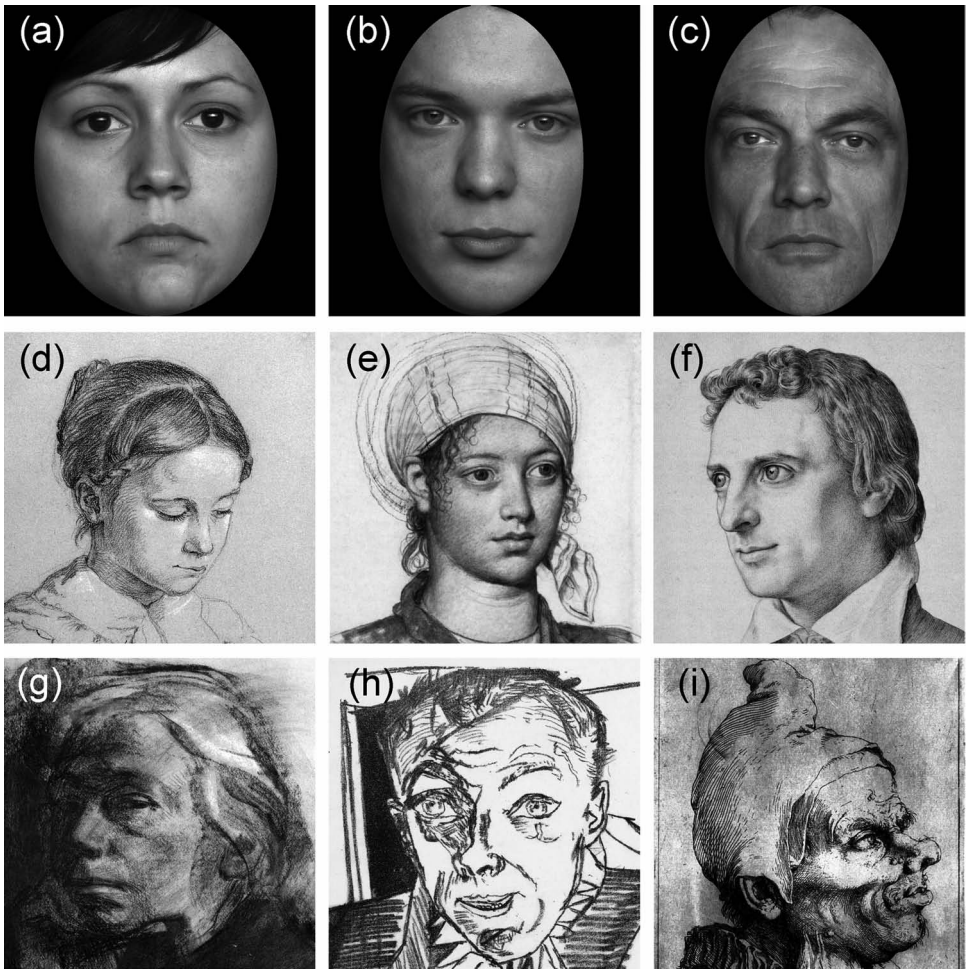

Figure 1. Examples of images used in the adaptation experiments. (A–C) Modified images of the Max Planck FACES database. (D–F) Images of original greyscale art portraits from various artists in different painting styles that have been rated as attractive. D: Friedrich von Nerly (ca. 1828, $M = 1.35$), E: Jean-Auguste-Dominique Ingres (1816, $M = 1.82$), F: Julius Schnorr von Carolsfeld (1817, $M = 2.07$). (G–I) Images of original greyscale art portraits that have been rated as not attractive. G: Käthe Kollwitz (1924, $M = 3.55$), H: Max Beckmann (1918, $M = 3.80$), I: José de Ribera (1622, $M = 4.00$).

2.1.1.5 Procedure.

The experiment consisted of five different phases. In a baseline phase, participants first rated the attractiveness of the test stimuli before adaptation. In a following adaptation phase, participants adapted to either 20 attractive or 20 unattractive faces. The effects of this adaptation were subsequently established in a post-adaptation phase during which participants were again asked to rate the attractiveness of test stimuli. After a short break, participants then adapted to the opposite attractiveness condition, the effects of which were again examined in a final post-adaptation phase. The order of adaptation conditions was counterbalanced across participants. For each observer, the sequence of the images was randomized.

In the baseline phase, a question mark was presented first (800 ms), followed by the test image (600 ms), and a blank screen (1600 ms). Participants were asked to evaluate the attractiveness of the presented face on a rating scale by pressing one of four labelled keys. In the subsequent adaptation phase, 20 adaptor images were shown three times in randomized order and were passively viewed by the participants. Exposure duration was three seconds for each adaptation stimulus. The adaptation block had a total duration of three minutes (180 s) and was immediately followed by the post-adaptation phase during which participants rated the attractiveness of the test images. Each post-adaptation trial began with the presentation of two top-up adaptor images (3000 ms each), followed by a grey question mark (800 ms), the target image (600 ms), and a blank screen (1,600 ms). The choice of timing parameters was guided by earlier research on the timecourse of high-level face aftereffects (Rhodes, Jeffery,

Clifford, & Leopold, 2007). To avoid or reduce transfer effects from contrastive adaptation conditions (Kloth & Schweinberger, 2008), participants played a non-visual online game for about five minutes following completion of the first adaptation condition. Following this break, a second block was run, in which participants adapted to the opposite attractiveness condition. Each participant completed 80 trials per condition, leading to a total number of 240 trials in the main experiment.

2.1.2 Results

Mean attractiveness ratings of test faces were calculated for each of the three adaptation conditions and each participant. The results were entered into a one-way analysis of variance (ANOVA) considering Adaptation Condition (baseline, adapted to unattractive faces, adapted to attractive faces) as within-subject factor. The analysis revealed a significant effect of Adaptation Condition, $F(2, 68) = 47.21$, $p < 0.001$, $\eta_p^2 = 0.58$, reflecting increased perceived attractiveness compared with the baseline condition ($M = 2.87$, $SD = 0.41$) after adaptation to unattractive faces ($M = 2.71$, $SD = 0.47$), $t(34) = 2.93$, $p < 0.01$, and reduced perceived attractiveness after adaptation to attractive faces ($M = 3.21$, $SD = 0.32$), $t(34) = -6.55$, $p < 0.001$ (see Figure 2).

2.2 Experiment 1B: Adaptation to facial attractiveness within a restricted age range

The face stimuli in Experiment 1A covered a relatively substantial age range (19–55 years). Although the allocation of individual face pictures to adaptation conditions (attractive vs. unattractive adaptors) was purely based on the attractiveness ratings of the individual pictures, the average age of the adapting faces happened to differ between the attractive and unattractive adaptors. As earlier research has indicated that adaptive recalibration also governs the perception of facial age (Schweinberger et al., 2010), it is difficult to rule out the possibility that the confound of age and attractiveness of the adaptation stimuli used in Experiment 1A contributed to the present pattern of results. In order to avoid such a potential influence of age adaptation, we replicated Experiment 1A using only young adult faces as stimuli.

2.2.1 Methods

2.2.1.1 Participants.

Experiment 1B was carried out by 30 new participants (18–27 years, $M = 21.7$ years, 12 male).

2.2.1.2 Stimuli.

A subset of 60 stimuli from Experiment 1A was used. Pictures showed faces aged between 19 and 27 years. Fifteen images of high and 15 images of low attractiveness were chosen as attractive and unattractive adaptors, respectively, and 30 images of intermediate attractiveness were used as test images ($M \pm SD = 1.73 \pm 0.13$, 2.97 ± 0.27, and 2.40 ± 0.21, respectively). Physical stimulus parameters were equivalent to those reported in Experiment 1A.

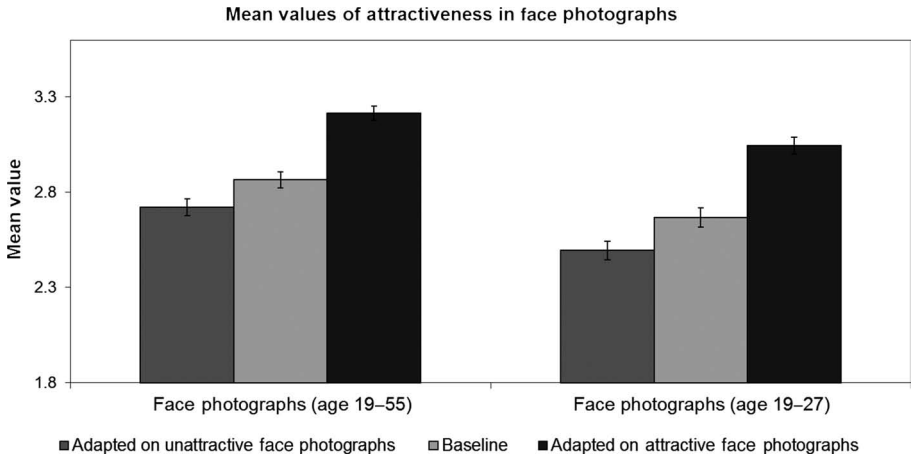

Figure 2. Overview of the adaptation effects on attractiveness of face photographs. Experiment 1A = face photographs from persons in the age from 19 to 55. Experiment 1B = photographs of faces from persons in the age from 19 to 27. Higher mean values indicate a lower attractiveness. Error bars show standard error of the mean.

2.2.1.3 Procedure.

The procedure was analogous to that of Experiment 1A. Each participant completed 30 trials per condition, leading to a total number of 90 trials in the main experiment.

2.2.2 Results and discussion

As before, mean attractiveness ratings of test faces were calculated for each of the three adaptation conditions and each participant. These data were entered into a one-way ANOVA considering Adaptation Condition (baseline, adapted to unattractive faces, adapted to attractive faces) as within-subject factor. The analysis revealed a significant effect of Adaptation Condition, $F(2, 58) = 27.24$, $p < 0.001$, $\eta_p^2 = 0.48$, reflecting increased perceived attractiveness compared with the baseline condition ($M = 2.77$, $SD = 0.30$) after adaptation to unattractive faces ($M = 2.55$, $SD = 0.35$), $t(29) = 4.66$, $p < 0.001$, and reduced perceived attractiveness after adaptation to attractive faces ($M = 2.93$, $SD = 0.35$), $t(29) = -2.74$, $p < 0.05$ (see Figure 2).

Overall, Experiments 1A and 1B revealed a clear pattern of contrastive aftereffects. We found decreased levels of perceived attractiveness after adaptation to attractive faces, and increased perceived attractiveness for the same probe faces after adaptation to unattractive faces. The observed effect appears to be asymmetrical, in that adaptation to attractive faces induces larger aftereffects than adaptation to unattractive faces.

3 Experiment 2: Adaptation to attractiveness and beauty of art portraits

In Experiment 2, we investigated whether the adaptive recalibration of attractiveness perception observed for naturalistic photographs of faces in Experiment 1 extends to artificial depictions of human faces in art portraits. For such an investigation it is important to consider, however, that art portraits can be judged on two different aesthetic dimensions, i.e. the attractiveness of the displayed face and the beauty of the artwork itself. In the following study, we therefore investigated effects of adaptation to both the attractiveness of the depicted face (Experiment 2A) and the beauty of the overall composition of the artwork (Experiment 2B).

3.1 Experiment 2A: Adaptation to the attractiveness of faces displayed in art portraits

3.1.1 Methods

3.1.1.1 Participants.

Experiment 2A was carried out by 20 new participants (19–29 years, $M = 21.9$ years, 5 male).

3.1.1.2 Stimuli.

Stimuli were images of 104 art portraits of men and women, all greyscale line drawings. Portraits were by various artists from the 14th to the 20th century and drawn in different artistic styles (see Figure 1, D–I). The artworks were digitized by scanning reproductions from different art books and images were cut down to square face portraits. Care was taken that the reproductions were of high quality and did not contain obvious artefacts. Digitization was carried out with the help of a commercial scanner (Perfection 3200 Photo, Seiko Epson Corporation, Nagano, Japan). Each image was resized to 1024 × 1024 pixels. In order to determine the perceived attractiveness of each face, pictures were rated according to their attractiveness on a scale from 1 (very attractive) to 4 (very unattractive) by the same viewers who had also rated the face photographs used in Experiment 1. Participants were told that attractiveness was defined as the physical allurement of a face.

According to their mean attractiveness ratings, art portraits were then allocated to one of three sets (20 images with low, 64 images with intermediate, and 20 images with high attractiveness, $M \pm SD = 3.66 \pm 0.14$, 2.79 ± 0.39, and 1.90 ± 0.20, respectively). In the main experiment, stimuli of high and low attractiveness served as attractive and unattractive adaptors, respectively, while portraits of intermediate attractiveness served as test stimuli.

3.1.1.3 Procedure.

The procedure was analogous to Experiment 1A but art portraits were used as adaptors and target images. There were 64 trials per condition, leading to a total number of 192 trials in the main experiment.

3.1.2 Results and discussion

Mean attractiveness ratings of test faces were calculated for each of the three adaptation conditions and each participant. The results were entered into a one-way ANOVA considering Adaptation Condition (baseline, adapted to unattractive faces, adapted to attractive faces) as within-subject factor. The analysis revealed a significant effect of Adaptation Condition, $F(2, 38) = 31.45$, $p < 0.001$, $\eta_p^2 = 0.62$, reflecting lower scores on the attractiveness rating scale (indicating larger perceived attractiveness) compared with the baseline condition ($M = 2.73$, $SD = 0.24$) after adaptation to unattractive faces ($M = 2.41$, $SD = 0.29$), $t(19) = 4.64$, $p < 0.001$, and significantly higher scores on the attractiveness rating scale (indicating lower perceived attractiveness) after adaptation to attractive faces ($M = 2.92$, $SD = 0.30$), $t(19) = -3.49$, $p < 0.01$ (see Figure 3).

3.2 Experiment 2B: Adaptation to beauty of art portraits

3.2.1 Methods

3.2.1.1 Participants.

Experiment 2B was carried out by 20 new participants (19–25 years, $M = 21.3$ years, 4 male).

3.2.1.2 Stimuli.

We used the same stimuli as in Experiment 2A. In order to determine the perceived beauty of each art portrait, images had also been rated according to their beauty on a scale from 1 (very beautiful) to 4 (not beautiful, i.e. "ugly"). In accord with philosophical theories (see, for example, Kant, 1790), it was stated to the participants that beauty should be considered as a property of images and refers to the pleasure derived from the composition of the image (or artwork). They were explicitly instructed not to take the attractiveness of the faces into account. For experimental design, see Experiment 1A.

According to their mean beauty ratings, stimuli were allocated to one of three sets (20 images of low perceived beauty, 64 images of intermediate beauty, and 20 images of high perceived beauty, $M \pm SD = 3.25 \pm 0.17$, 2.39 ± 0.30, and 1.78 ± 0.11, respectively). In the main experiments, pictures rated as high and low in beauty served as beautiful and not beautiful adaptors, respectively, while stimuli of intermediate beauty served as test stimuli.

3.2.1.3 Procedure.

The procedure was analogous to Experiment 2A.

3.2.2 Results and discussion

Mean beauty ratings of test faces were calculated for each of the three adaptation conditions and each participant. The results were entered into a one-way ANOVA considering Adaptation Condition (baseline, adapted to beautiful images, adapted to ugly images) as within-subject factor. The analysis revealed a significant effect of Adaptation Condition, $F(2, 38) = 14.24$, $p < 0.001$, $\eta_p^2 = 0.43$,

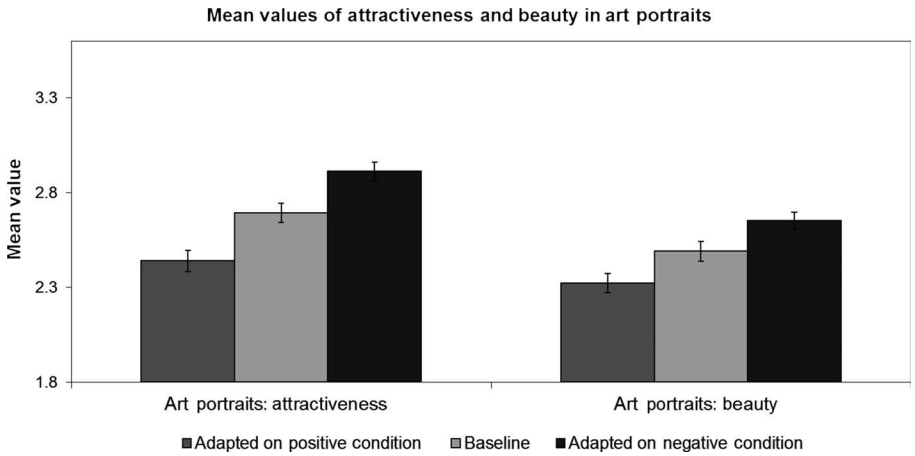

Figure 3. Overview of the adaptation effects on attractiveness and beauty of art portraits. Experiment 2A = attractiveness ratings. Experiment 2B = beauty ratings. Higher mean values indicate a lower attractiveness. Error bars show standard error of the mean.

reflecting lower scores on the beauty rating scale (indicating larger perceived beauty) compared with the baseline condition ($M = 2.50$, $SD = 0.32$) after adaptation to "ugly" images ($M = 2.33$, $SD = 0.37$), $t(19) = 2.30$, $p < 0.05$, and significantly higher scores on the rating scale (indicating lower perceived beauty) after adaptation to beautiful images ($M = 2.66$, $SD = 0.35$), $t(19) = -3.16$, $p < 0.01$ (see Figure 3).

Experiments 2A and 2B revealed aftereffects when art portraits rather than face photographs (as in Experiment 1) were used as adaptors and test stimuli. These findings suggest that effects of adaptation to attractiveness in face images are not restricted to naturalistic face pictures but can also be observed for artificial portraits. Moreover, the perception of beauty—another aesthetic concept—was shown to be adaptively recalibrated as well.

In philosophical tradition, attractiveness and beauty are closely related but distinct aesthetic concepts. However, it is still an open question, in which way they are associated with each other. Therefore, we determined the degree to which attractiveness and beauty ratings were correlated in the present set of images. We found a significant correlation, $r_s(38) = 0.63$, $p < 0.001$, between beauty and attractiveness ratings of art portraits (Figure 5).

4 Experiment 3: Domain-specificity of face attractiveness aftereffects

Experiments 1 and 2 revealed that the perception of attractiveness of both face photographs and art portraits can be influenced by prior exposure to attractive or unattractive stimuli of the same domain. In Experiment 3, we explored the domain-specificity of these aftereffects. Because we were primarily interested in alterations of attractiveness ratings of veridical face photographs by different adaptors, we tested whether or not adaptation to attractive or unattractive art portraits would change participants' subsequent perceived attractiveness of veridical face photographs.

4.1 Methods

4.1.1 Participants

Experiment 3 was carried out by 20 new participants (18–24 years, $M = 19.6$ years, 2 male).

4.1.2 Stimuli

As adaptors, we used 20 art portraits for which the depicted faces were rated as attractive and 20 art portraits for which faces were rated as unattractive. Considering that art portraits can differ both with respect to the attractiveness of the face and the beauty of the composition, as detailed above, we ensured that beauty ratings of the attractive and unattractive adaptor images were of comparable levels (for attractive adaptors: attractiveness: $M \pm SD = 1.90 \pm 0.20$, beauty: $M \pm SD = 2.01 \pm 0.33$; for unattractive adaptors: attractiveness: $M \pm SD = 3.02 \pm 0.40$, beauty: $M \pm SD = 2.01 \pm 0.21$). Target images were always face photographs, specifically we used the 80 face images of intermediate attractiveness ratings from Experiment 1A ($M \pm SD = 2.81 \pm 0.35$).

4.1.3 Procedure

Participants were asked to rate target images for attractiveness. The procedure was analogous to Experiment 1A.

4.2 Results and discussion

Mean attractiveness ratings of test faces (face photographs) were calculated for each of the three adaptation conditions and each participant. The results were entered into a one-way ANOVA considering Adaptation Condition (baseline, adapted attractive art portraits, adapted to unattractive art portraits) as within-subject factor. The analysis revealed no significant effect of Adaptation Condition, $F(1.45, 27.46) = 3.14$, $p = 0.074$, reflecting no significant change in attractiveness ratings compared with the baseline condition ($M = 3.03$, $SD = 0.33$), neither after adaptation to art portraits of attractive faces ($M = 2.97$, $SD = 0.33$), nor after adaptation to art portraits of unattractive faces ($M = 3.02$, $SD = 0.33$) (see Figure 4).

Overall then, the results of Experiment 3 provide little evidence for the existence of a cross-domain aftereffect in the perception of attractiveness. This is remarkable when considering that both adaptor and test stimuli were depictions of faces, and when considering that Experiments 1 and 2 had revealed clear patterns of contrastive aftereffects in the perception of attractiveness. Thus, for both

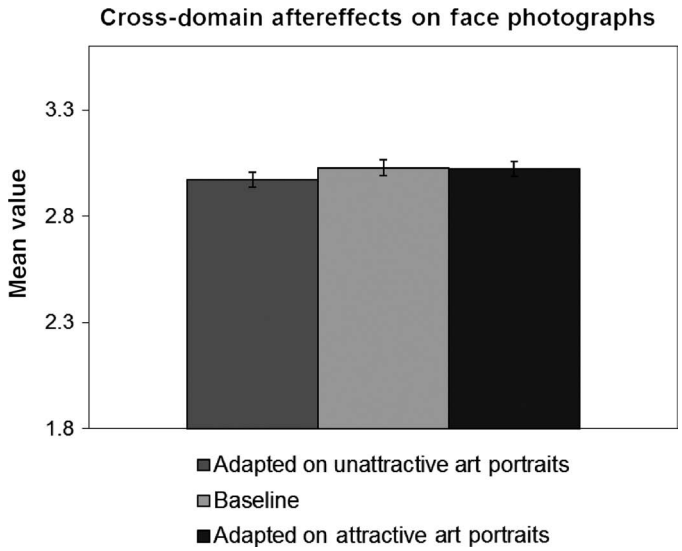

Figure 4. Adaptation effects on attractiveness of face photographs after adaptation on unattractive and attractive art portraits (Experiment 3). Higher mean values indicate a lower attractiveness. Error bars show standard error of the mean.

face photographs and art portraits, clear attractiveness aftereffects emerged when adaptor and test stimuli came from the same image domain.

In order to directly compare the cross-domain effects in Experiment 3 with the within-domain aftereffects for the same test faces in Experiment 1A, we performed an additional ANOVA with repeated measures on Adaptation Condition with Experiment (Experiments 1A and 3) as between-subjects factor. This analysis revealed a highly significant effect of Adaptation Condition, $F(2, 106) = 31.78$, $p < 0.001$, $\eta_p^2 = 0.38$. Importantly, the interaction of Adaptation Condition and Experiment was also significant, $F(2, 106) = 15.68$, $p < 0.001$, $\eta_p^2 = 0.23$, which directly demonstrates a significant difference between the pattern of absent cross-domain aftereffects in Experiment 3 and the pattern of systematic within-domain aftereffects in Experiment 1A for the same set of face photographs.

5 Discussion

In the present series of experiments, we investigated effects of adaptation to facial attractiveness on the perceived attractiveness of veridical non-morphed face photographs and artistic portraits of human faces. We found a clear pattern of contrastive aftereffects when adaptation and test stimuli belonged to the same domain, i.e. when they were both either veridical face photographs (Experiment 1) or art portraits (Experiment 2). After exposure to images displaying faces rated as highly attractive, participants evaluated test faces as significantly less attractive than before adaptation. After exposure to faces rated as relatively unattractive, test faces were rated as significantly more attractive than in the baseline phase. Importantly, even though similar contrastive effects were observed for both photographs and art portraits, results from Experiment 3 strongly suggest a domain-specificity of attractiveness aftereffects. Such aftereffects were eliminated when adaptors were art portraits and face photographs were shown as test stimuli.

The results of Experiment 1 suggest that, along with facial identity (Leopold et al., 2001; Rhodes & Jeffery, 2006), facial expression, gender, ethnicity (Webster et al., 2004; Webster & MacLin, 1999) and age (Schweinberger et al., 2010), attractiveness is another complex feature of the human face the perception of which is adaptively recalibrated in a contrastive manner. Our work is closely related to a study by Rhodes et al. (2003), who reported that the perceived attractiveness of a face varies along with changes in the perceived normality induced by adaptation to face distortions (see also Rhodes et al., 2009, for similar findings). Our data extend these findings by showing that attractiveness ratings are not only influenced by adaptation to modified facial configurations, but also by adaptation to facial attractiveness itself.

The stimuli used here were original unaltered face photographs and were allocated to attractiveness conditions based on ratings that were most likely driven by those factors that have earlier been described as determinants of facial attractiveness. In line with this, attractive faces serving as adaptors

might be particularly symmetric, average, and gender dimorphic, whereas unattractive faces might be systematically characterized by lower scores on these attributes. Adaptation to attractive faces might therefore partly decrease the perceived attractiveness of an intermediate test face because it appears slightly less symmetric, less average, and less gender dimorphic as a consequence of adaptation.

5.1 Asymmetry of adaptation to attractive versus unattractive faces

An interesting observation was that in Experiment 1, adaptation to attractive faces appeared to induce stronger aftereffects than adaptation to unattractive faces. This asymmetry may be driven by differences in the adaptive power of attractive and unattractive adaptors. We had selected an equal number of faces with the highest and lowest attractiveness ratings as unattractive and attractive adaptors, respectively. In Experiment 1A, the most attractive faces happened to deviate in attractiveness from the intermediate test faces somewhat more than the most unattractive faces. Earlier research has shown that face identity aftereffects (Jeffery et al., 2011) as well as configural face aftereffects (Robbins, McKone, & Edwards, 2007) increase as the perceptual distance between adaptor and test increases. In line with this pattern, we found that attractive adaptors, which deviated more strongly in attractiveness from test faces, induced larger aftereffects than unattractive faces.

Importantly, effects of adaptation to facial attractiveness were not restricted to naturalistic face photographs. Experiment 2 demonstrates that the perception of attractiveness of drawn faces displayed in art portraits is similarly affected by prior exposure to attractiveness in these portraits. Despite the similarity of the overall aftereffects observed for face photographs and art portraits, a noteworthy difference is that the aftereffects induced by attractive and unattractive art portraits are largely symmetrical. Further supporting our potential explanation for the asymmetry in face aftereffects, differences in attractiveness between attractive and intermediate art portraits were almost identical to differences between unattractive and intermediate portraits. This equidistance will have led to symmetrical aftereffects in both conditions.

5.2 Absence of cross-domain aftereffects

Although we found clear patterns of contrastive aftereffects in the perception of attractiveness when adaptor and test stimuli came from the same image domain (Experiments 1 and 2), the results of Experiment 3 provide no evidence for the existence of cross-domain aftereffects. It may be argued that the average rating of the test photographs was somewhat closer to the attractive and non-attractive average ratings in Experiment 3 than in Experiment 1. However, these differences are rather small and unlikely to explain the complete absence of an adaptation effect. Instead, this finding may provide important information about the level at which adaptation takes place. While a pattern of cross-domain aftereffects would have been indicative of a higher order, conceptual or integrative level of adaptation, the absence of cross-domain aftereffects in the present study suggests that attractiveness adaptation occurs at an earlier, perceptual stage of high-level vision.

The present results therefore provide an interesting contrast to recent demonstrations of cross-domain adaptation in the perception of facial identity of familiar people (Hills, Elward, & Lewis, 2012), and of cross-species adaptation in the perceived cuteness of infant faces (Golle, Lisibach, Mast, & Lobmaier, 2013). However, an absence of cross-domain adaptation effects was also found in a study on viewpoint adaptation by Fang, Ijichi, and He (2007), who reported aftereffects within, but not across object categories such as faces, cars, and wire-like objects (Fang et al., 2007). Our study raises the additional possibility that some aftereffects are not only specific to a certain stimulus category, but are even sensitive to the style of the graphic representation within the same category—in this case human faces. It is highly plausible that the human face perception system has evolved based on, and is specialized for, the perception and mental representation of real human faces. Obviously, face photographs have a much higher resemblance with actual human faces, i.e. they are more realistic, than art portraits. Most importantly, pronounced differences in texture and skin surface topography between the two domains, which have recently been identified as important factors for face recognition (Fink & Matts, 2008) and the evaluation of facial attractiveness (Hume & Montgomerie, 2001), might prohibit a transfer of the attractiveness aftereffect from art portraits to photographs of faces. This may be particularly so because the present art portraits were essentially devoid of texture information, as is typical for line drawings of faces. While this may well be an explanation of the absence of cross-domain aftereffects in the present study, it should be noted that we cannot exclude the possibility that such effects could be demonstrated if art portraits were used that contain additional information about surface reflectance, such as in the case of more realistic paintings.

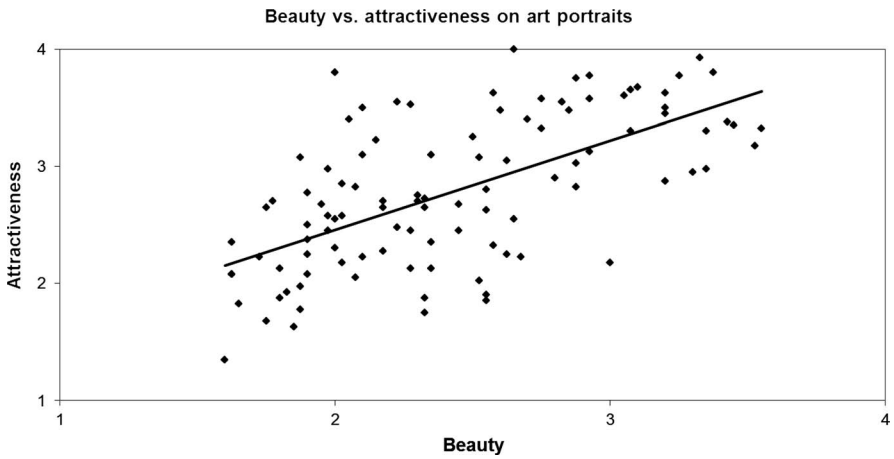

Figure 5. Correlation between attractiveness and beauty ratings for art portraits ($N = 104$; $r_s = 0.63$; $p < 0.001$).

In this respect, it is of interest to note that the depicted art portraits varied in style and included realistic and less realistic (e.g. cubist) paintings. It is our impression that the top-rated art portraits tended to be the more realistic ones (Figure 1). However, even the more attractive and realistic art portraits did not lead to an adaptation effect although they are more similar to veridical face photographs.

5.3 Face attractiveness versus image beauty

Art portraits are of particular interest for research on aesthetic values because, in addition to the attractiveness of the faces depicted, they can also evoke a sense of beauty derived from their global image composition. It is noteworthy that we observed aftereffects in aesthetical judgements not only for attractiveness, but also for beauty of art portraits. Previously, aftereffects on artworks had been shown only in a preliminary conference report, and only for adaptation to a single style of painting (Carbon, Leder, & Ditye, 2007), but not for the aesthetic appreciation. In our experiments, we explicitly instructed the participants that we defined attractiveness as a property of the face while beauty was considered to be a property of the image. Indeed, some images received high beauty ratings although the displayed faces were perceived as unattractive, and the reverse situation could also be encountered to a limited extent (cf., Figure 5). Nevertheless, we found a high correlation between ratings of attractiveness and beauty for the set of artworks studied here. A possible reason for this correlation could be participants' tendency to rate faces depicted in beautiful images as more attractive. This finding might be related to a recent demonstration of a strong influence of image characteristics—over and above an influence of facial identity—on perceived facial attractiveness (Jenkins, White, Van Montfort, & Burton, 2011). Alternatively, it is possible that artists tend to emphasize the attractiveness of a face by composing the artwork more beautifully. Regardless of which explanation holds, both the pattern of aftereffects and the correlational analysis hint at a strong interdependency of attractiveness and beauty, possibly reflecting the common overlap with a superordinate aesthetical idea.

6 Conclusion

We reported a series of experiments that show aftereffects of adaptation to facial attractiveness, in both face photographs and art portraits. Our findings suggest that in addition to comparatively objective dimensions on which faces differ (e.g., age or gender), the perception of attractiveness is also subject to adaptive recalibration. The present data extend our understanding of the mechanisms underlying facial attractiveness perception, in showing that the perceived attractiveness of faces not only changes as an indicator of renormalization following adaptation to configural distortions (Rhodes et al., 2003), but also following adaptation to facial attractiveness itself. Aftereffects occur for both photographs and art portraits of faces, but do not transfer across stimulus domains, suggesting that adaptation does not occur at a conceptual level of aesthetic representation. Rather, the aftereffects observed here seem to result from perceptual adaptation at high levels of the visual system.

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