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Primacy in the Effects of Face Exposure: Perception Is Influenced More by Faces That Are Seen First

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ABSTRACT

Exposure to faces biases perceptions of subsequently viewed faces. In literature on memory, there are prominent effects of primacy in which people remember things better if they are at the beginning of a list. Here, we tested for primacy in face exposure by exposing people to faces that had been transformed in opposite directions twice. For example, in one condition, we exposed people to "plus" faces and measured how much they thought plus faces appeared normal and then exposed them to "anti" faces and again measured how much they thought plus faces appeared normal. A primacy effect would be seen if, after the second measurement, judgments of plus faces were unchanged from the first measurement whereas no primacy effect would be seen if, after the second exposure, judgments of plus faces were different from the first measurement. We found no change in normality judgment between the first and second judgments, supporting a primacy effect. Our results indicated a primacy effect in adaptation in which faces seen first affected perception more than faces seen later. This primacy effect could lead to long-lasting effects of exposure to faces.

SCIENTIFIC ABSTRACT

Exposure to faces biases perceptions of subsequently viewed faces such that faces similar to those seen previously are judged as more normal and attractive than they were before exposure. Here, we examine adaptation over time by adapting judges to faces manipulated in one direction and then exposing judges to an equivalent set of faces manipulated in the opposite direction to those previously seen. In the first adaptation phase, rating the attractiveness of faces transformed in identity increased the perceived normality of novel faces with characteristics similar to those viewed. In the second adaptation phase, when faces were transformed in opposite direction, no change in normality judgment from that seen after the first adaptation phase was observed (no interaction between adaptation order and adaptation condition, $F_{1,77} < 1$, $p = .51$, $\eta_p^2 = .006$). Our results indicated a primacy effect in adaptation in which faces seen first affected perception more than faces seen later. These results suggest that visual adaptation to faces is more complex than simple opponent-process adaptation in that it is not easily extinguished. Furthermore, this primacy effect could lead to long-lasting effects of visual adaptation.

Keywords: adaptation, facial, normality, representation, primacy
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Face adaptation, in which exposure to faces biases subsequent perceptions of novel faces (Leopold, O'Toole, Vetter, & Blanz, 2001; Leopold, Rhodes, Muller, & Jeffery, 2005; Little, DeBruine, & Jones, 2005; Rhodes, Halberstadt, & Brajkovich, 2001; Rhodes, Jeffery, Watson, Clifford, & Nakayama, 2003; Rhodes et al., 2004; Webster, Kaping, Mizokami, & Duhamel, 2004; Webster & MacLeod, 2011), is

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currently shedding new light on the processes of face perception. Adaptation has been used to probe questions of category in face processing with studies showing that upright and inverted faces (Rhodes et al., 2004) and male and female faces (Little et al., 2005) may have distinct representations in the brain. As a basic example, adaptation (exposure) to faces with increased eye-spacing causes novel faces with increased eye-spacing to be perceived as more normal than before this exposure (Little et al., 2005). Analogous face adaptation effects have been observed after exposure to faces varying in identity (Leopold et al., 2001; Rhodes et al., 2001), ethnicity (Webster et al., 2004), sex (Rhodes et al., 2004; Webster et al., 2004), and expression (Webster et al., 2004). Adaptation from exposure to faces also influences attractiveness judgments (Little et al., 2005; Rhodes et al., 2003).

Face adaptation effects are thought to reflect changes in the responses of neural mechanisms underlying face processing (Leopold et al., 2001, 2005; Moradi, Koch, & Shimojo, 2005; Rhodes et al., 2003, 2004; Webster et al., 2004; Webster & MacLeod, 2011). The effects of exposure during the context of an experiment appear to be relatively short lived, becoming weaker as the length of time after exposure increases (Leopold et al., 2005). In contrast, studies of repeated, long-term exposure have presented evidence consistent with more long-lasting effects (Carbon & Ditye, 2011, 2012; Carbon et al., 2007; Webster et al., 2004) and might suggest that, although adaptation can continually influence perception, exposure could influence long-term representations. Indeed, studies have shown that adaptation effects based on experimental exposure to manipulated faces can persist over 7 days (Carbon & Ditye, 2012).

Primacy and recency are major features of human memory. Well studied in terms of recalling lists, the primacy effect refers to the fact that the first items on a list are better recalled than items in the middle of a list, whereas the recency effect refers to the fact that the most recently noted items are also better recalled than items from the middle of a list (Murdock, 1962). The primacy effect is often explained via the greater potential for repetition in short-term memory of items first encountered (Phillips, Shiffrin, & Atkinson, 1967). The explanation of recency effects in memory has been that items recently encountered are held in limited capacity short-term buffer from which they are more easily retrieved (Phillips, Shiffrin, & Atkinson, 1967).

Here, we examine issues of primacy in adaptation to faces. Such effects are likely to occur via different mechanisms than those seen for memory because an average representation is changed for faces. Adaptation occurs because sustained stimulation with particular visual patterns fatigues the neurons that respond to that pattern, resulting in an aftereffect once the visual pattern is removed (see Carandini, 2000). This pattern of neuron response may lead to reduced responses to stimuli over time. Indeed, a reduction in response is observed in the phenomenon of repetition suppression or attenuation, in which repetitions of the same stimuli lead to decreased changes in brain activation relative to initial presentation during functional magnetic resonance imaging scans (Liu, Murray, & Jagadeesh, 2009). Such effects have been documented specifically in the face-sensitive region of the brain (fusiform face area), in which significant reduction in activation is observed for repeated faces (Yi, Kelley, Marois, & Chun, 2006). Given such effects, it is possible that adaptation effects for faces are most likely to be generated by faces seen early within a particular timeframe and that weaker adaptation effects would be seen based on faces that are seen later as long as those later faces were somewhat similar to the initially seen faces via this mechanism.

To test for primacy effects in face adaptation, we exposed participants to faces moved in one direction followed by a test of normality perception. This was subsequently followed by exposure to faces moved in the opposite direction and another test of normality perception. If normality judgments are still more in line with the original adaptation at the second testing, then this would be evidence for primacy in face adaptation. If normality judgments are changed or extinguished so that no effects of adaptation are evident in the second set of normality judgments, then the second exposure has counteracted the effects of the first exposure, as might be expected by simple opponent-process coding as seen in color vision (Hurvich & Jameson, 1957). We note that our definition of primacy may not strictly conform to the definitions used in memory research; rather, our definitions are useful in distinguishing whether either our first or second set of exposures had greater or lesser effects on normality perception.

Method

Participants

Participants were 79 individuals (48 women and 31 men, mean age = 29.4 years, *SD* = 10.1, range = 17–53) who were volunteers and of White ethnicity. Participants were recruited via a dedicated research website and selected for being of White ethnicity and older than 15 and less than 61 years of age.

Stimuli

All stimuli were constructed using established (Little et al., 2005; Rowland & Perrett, 1995; Tiddeman, Burt, & Perrett, 2001) techniques for manipulating the appearance of face images in an objective, systematic manner (for technical details, including mathematical algorithms, see Rowland & Perrett, 1995; Tiddeman et al., 2001). Stimuli were manufactured from a set of British White faces (mean age = 19.6 years, *SD* = 1.6, range = 17–24) and have been used in previous studies of adaptation (Little et al., 2005).

Twenty-five female composite images (2 original images in each) were transformed either 50% toward ("plus") or away ("anti") from an individual male face against a composite average male face (50 images), creating 50 images, 25 of each type (plus and anti). In other words, we computed the vector difference between a single male face and an average male face and then used this vector to transform the female composites. This method is comparable to that used by Leopold et al. (2001) to manipulate facial identity in previous studies of face adaptation. Five female composites (10 images each) were transformed in the same way, creating five pairs of images for use in the test phase (see Figure 1). Transforming images plus or anti in this way only changes idiosyncratic features that differentiate the individ-

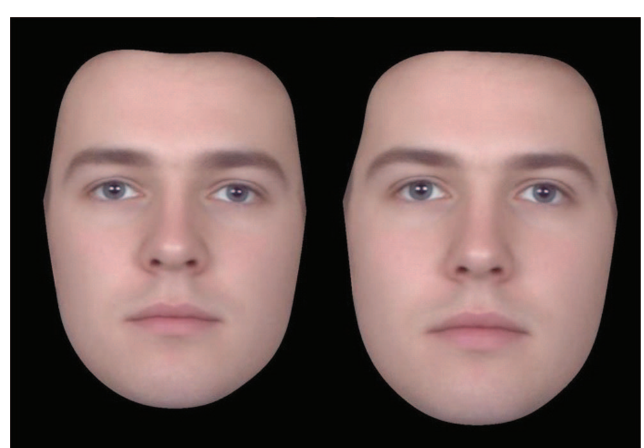

Figure 1. Face images varying in identity: plus (left) and anti (right).

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ual face from average; therefore, plus and anti images did not differ systematically in averageness because the transform represents an equal change in difference from the average in opposite directions (i.e., the images are equidistant from average).

Procedure

The experiment was remotely completed over the Internet. Studies have shown equivalent adaptation effects in online- compared with laboratory-based studies (Little, Hancock, DeBruine, & Jones, 2012). Participants were randomly assigned to one of two conditions in the adaptation phase (plus first/anti second, or anti first/plus second). In each condition, participants were first asked to rate the attractiveness (on a 7-point scale) of all 25 female faces of one type of transformation. After this first adaptation phase, participants were presented with 5 new pairs of face images, with each pair consisting of one anti and one plus version of a female composite (postadaptation test). Participants were asked to choose the face in each pair that appeared more "normal." Participants then repeated the same procedure, but they were exposed to the other type of transformation (second adaptation phase) before completing a second postadaptation test. The postadaptation test was the same for both first and second adaptation phases. All images in the adaptation phases were presented in a random order, and order and side of image presentation were randomized in the postadaptation tests.

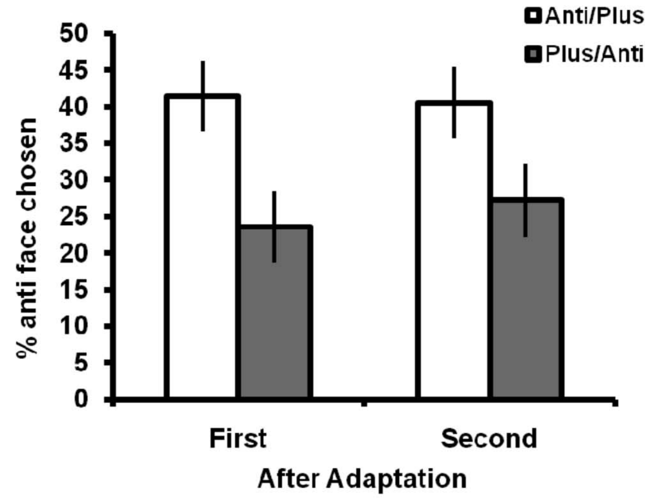
Results

Adaptation and Extinction

A mixed model analysis of variance (ANOVA; dependent variable: percentage of trials on which anti identity was preferred; within-participant factor: adaptation phase [first/second]; between-participant factor: adaptation condition [plus first/anti first]) revealed a significant main effect of adaptation condition ($F_{1,77} = 6.82$, $p = .011$, $\eta_p^2 = .081$, Figure 2 top) and no interaction between adaptation phase and adaptation condition ($F_{1,77} < 1$, $p = .51$, $\eta_p^2 = .006$). There was no significant main effect of adaptation phase ($F_{1,77} < 1$, $p = .71$, $\eta_p^2 = .002$). This indicated that there was no significant change in the direction or size of adaptation between the first and second adaptation condition. In other words, the adaptation effect generated in the first adaptation phase was unchanged after exposure to faces transformed in the reverse direction in the second adaptation phase. Adding sex of judge (male/female) as a between-participant factor and age as a covariate to the model had no effect on the pattern of data, and no additional main effects or interactions were significant (all $F_{1,74} < 2.52$, $p > .11$, $\eta_p^2 < .033$).

Additional one-way ANOVAs conducted separately for first and second adaptation phases (dependent variable: percentage of trials on which anti identity was preferred; between-participant factor: adaptation condition [plus first/anti first]) revealed a main effect of adaptation condition in the same direction for both first ($F_{1,77} = 6.91$, $p = .010$, $\eta_p^2 = .082$, Figure 2 top) and second ($F_{1,77} = 3.59$, $p = .062$, $\eta_p^2 = .045$, Figure 2 top) adaptations, although the latter was only close to significant. The lack of interaction between adaptation order and adaptation condition above indicates that although the effect appears weaker for the second adaptation, it was not significantly so.

Finally, we split the sample by adaptation condition to examine consistency across the first and second adaptation phases. Pearson product moment correlations revealed significant positive correlations for both anti face first ($r = .54$, $p < .001$) and plus face first ($r = .43$, $p = .007$) conditions. Paired sample *t* tests revealed no significant change in normality judgments across adaptation phase for both anti face first ($t_{39} = 0.20$, $p = .846$) and plus face first ($t_{38} = -0.76$, $p = .455$) conditions.



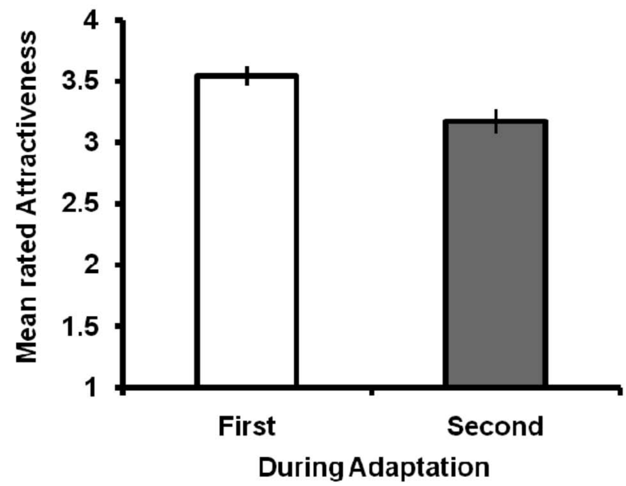


Figure 2. Mean choice of anti faces after exposure to either anti then plus or plus then anti faces (top) and mean attractiveness ratings during the first and second adaptation phases (bottom). Mean scores are presented with error bars representing ±1 *SEM*.

Rating Scores During the Adaptation Phases

Attractiveness ratings were collected as a task during both of the adaptation phases. A paired-sample *t* test between mean attractiveness scores in the first adaptation phase and the second adaptation phase revealed a significant effect of order ($t_{78} = 5.5$, $p < .001$, $d = 1.25$, Figure 2 bottom) such that images seen first were rated as more attractive than the images seen second. A Pearson product–moment correlation revealed that mean ratings by individuals were positively related between the two phases ($r_{77} = 0.73$, $p < .001$).

Cronbach's α was calculated as a measure of interrater reliability of the attractiveness judgments made in the adaptation phases. This revealed high interrater agreement for the four sets of faces rated: anti first ($\alpha = .957$), anti second ($\alpha = .928$), plus first ($\alpha = .942$), and plus second ($\alpha = .946$). This indicated no change in the extent of agreement between judges according to whether faces were rated first or second.

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Discussion

Our results demonstrated that facial adaptation occurred only after the first phase of exposure and that a subsequent equivalent exposure to faces, representing the opposite shape change to that seen originally, did not significantly change the original exposure effects. It appeared that the effects of initial exposure carried over through and past the second adaptation phase (i.e., we were unable to extinguish or significantly modify the effects of initial exposure). Our results indicate a primacy effect in face adaptation or that there is a changing degree of flexibility in the representation of faces in which representations can initially be altered by exposure but become less changeable based on immediately subsequent exposure.

Previous studies have suggested that changes to mental representations after exposure to faces are relatively short-lived. However, in humans, attraction to individuals with parental traits (i.e., imprinting-like effects) has been shown (Little, Penton-Voak, Burt, & Perrett, 2003; Perrett et al., 2002), suggestive of long-lasting effects of exposure. For example, one previous study has examined the potential for long-term exposure to influence normality judgments in which White American faces were seen as increasingly more normal looking the longer Asian participants had lived in the United States (Webster et al., 2004). Other studies have additionally demonstrated that exposure effects can be long lasting over days (Carbon & Ditye, 2011; Carbon et al., 2007), and such long-lasting effects can be detected in ecologically valid conditions outside of the laboratory in which they are induced (Carbon & Ditye, 2012). Our findings may then shed light on the mechanism by which long-term effects of exposure occur.

The primacy effects seen here potentially relate to neuronal fatigue and repetition attenuation. Neurons may be limited in the amount of adaptation that can occur given that such effects are based on fatigue. In other words, within a certain space of time, adaptation may have limited flexibility. Because repetitions of the same stimuli lead to decreased changes in brain activation (Liu et al., 2009; Yi et al., 2006), it is possible that faces seen in our second adaptation phase produced lower activation. This seems especially likely for our stimuli because the faces used were identical in the first and second adaptation phase except for the transformation of the eye region. In this way, repetition attenuation of repeated face stimuli could lead to adaptation effects being stronger for initial faces seen and weaker for faces encountered later, at least within the time frame of our study.

Another alternative, or additional explanation, may be that because attractiveness judgments in the second adaptation phase are decreased from the first, adaptation in the first phase decreases the reward value of faces in the second phase, which in turn reduces their effect on visual adaptation. The exact mechanism for this effect is unclear, but it could potentially be explained by attentional processes in which attention is diverted from relatively unrewarding faces (Shimojo, Simion, Shimojo, & Scheier, 2003). However, some authors have argued that robust face aftereffects can take place when attention during adaptation is limited (Moradi et al., 2005). Although we do not discount attentional effects here, individuals appear to behave in the same way to the faces in terms of the attractiveness ratings they give them across both phases, as evidenced by the equivalent agreement between judges in different phases. This is suggestive that participants were indeed attending to the faces in a similar way in each phase (i.e., a relative lack of attention in the second adaptation phase should be evidenced by lower interrater agreement than for the first adaptation phase, which was not found).

As well as potentially influencing attention, reward value may also be more directly coupled to certain images via exposure, which subsequently affects the process of adaptation. For example, after exposure to the anti faces, the anti faces become more attractive (Little et al., 2005; Rhodes et al., 2003); therefore, plus faces have less effect on representations. Indeed, this explanation is in line with research that demonstrated that attractive faces appear to have more influence in changing representations of normality than less attractive faces (Jones, DeBruine, & Little, 2008). This would also suggest that neural tuning via exposure is not a simple process and that neurons that code faces may be tied to the reward system.

In conclusion, here we show evidence of primacy in face exposure whereby faces seen early in our study had more impact on perception than faces seen later. The effects observed here are also further evidence that aftereffects due to exposure to faces cannot be explained simply by retinal (i.e., low-level) adaptation via simple opponent processes because they are not easily extinguished. These data suggest that the role of neuronal fatigue, reward value, and attentional bias may be fruitful avenues for future research into face adaptation.

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