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Decision-dependent aftereffects for faces

Christian Walther [a,b,c,*], Stefan R. Schweinberger [a,b,d], Gyula Kovács [a,b,c,e]

[a] DFG Research Unit Person Perception, Friedrich-Schiller-University of Jena, Germany
[b] Institute of Psychology, Friedrich-Schiller-University of Jena, Germany
[c] Institute of Psychology, University of Regensburg, Germany
[d] Department for General Psychology and Cognitive Neuroscience, Friedrich-Schiller-University of Jena, Germany
[e] Department of Cognitive Science, Budapest University of Technology and Economics, Budapest, Hungary

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ABSTRACT

Adaptation-related aftereffects (AEs) have been found in the perception of face identity, in that perception of an ambiguous face is typically biased away from the identity of a preceding unambiguous adaptor face. In previous studies, we could show that both perceptual ambiguity and physical similarity play a role in determining perceived face identity AEs, Cortex 49 (2013) 1963–1977, Plos One 8 (2013) e70525. Here, we tested further the role of ambiguity by manipulating participants' task such that the very same target stimuli were either ambiguous or unambiguous regarding stimulus classification. We created two partially overlapping continua spanning three unfamiliar face identities each, by morphing identity A via B to C, and B via C to D. In a first session, participants were familiarised with faces A and C and asked to classify faces of the A–B–C continuum as either identity A or C in an AE paradigm. Following adaptation to A or C, we observed contrastive AEs for the ambiguous identity B, but not for the unambiguous identities A or C. In a second session, the same participants were familiarised with faces B and D, followed by tests of AEs for the B–C–D continuum now involving a B–D classification task. We again observed contrastive AEs but only for target identity C (ambiguous for the decision) and not for B or D (unambiguous). Our results suggest that perceptual ambiguity, as given by the task-context, determines whether or not AEs are induced.

1. Introduction

In our social environment the human face is a stimulus of outstanding importance, as it carries information about a person's identity, gender, age, or emotional state. However, the perception of a given face can be influenced by recent perceptual experiences (for a review see Clifford & Rhodes, 2005). In the case of adaptation-related aftereffects (AEs), the perception of a test face is contrastively biased away from the features of a preceding adaptor face (for a review see Webster & MacLeod, 2011). For example, after prolonged exposure (i.e., adaptation) to a female face, an androgynous face is more likely perceived as male, whereas the same androgynous face is more likely perceived as female following adaptation to a male face (e.g., Webster et al., 2004). Such AEs have been described previously for lower-level stimulus qualities such as colour, texture (Durgin & Proffitt, 1996), line orientation (Clifford, Wenderoth, & Spehar, 2000), or motion (Anstis, Verstraten, & Mather, 1998; Clifford, 2002). Interestingly, there is also growing evidence for AEs in the perception of socially relevant information in faces, such as a person's identity (Hills, Elward, & Lewis, 2010; Hills & Lewis, 2012; Leopold et al., 2001; Rhodes et al., 2007; Walther et al., 2013), gender (Kloth, Schweinberger, & Kovács, 2010; Kovács et al., 2006, 2007; Webster et al., 2004), ethnicity, emotional expression (Webster et al., 2004), gaze direction (Jenkins, Beaver, & Calder, 2006; Kloth & Schweinberger, 2008), age (Schweinberger et al., 2010), or trustworthiness (Keefe et al., 2013).

In the first study on face identity AEs, Leopold et al. (2001) created so-called "anti-faces", i.e., morphs that lie beyond the average face on a trajectory connecting an original face and the average face in face space (Valentine, 1991), and showed that adaptation to such anti-faces shifted the perception of the average face away from the anti-faces and towards the original identity. While that study and some others (Leopold et al., 2005; Rhodes, Evangelista, & Jeffery, 2009; Rhodes & Jeffery, 2006) used unfamiliar faces with which participants were experimentally familiarised, other recent studies demonstrated face identity AEs for well-known, familiar

* Corresponding author at: DFG Research Unit Person Perception, Department for General Psychology and Cognitive Neuroscience, Friedrich-Schiller-University of Jena, Leutragraben 1, 07743 Jena, Germany. Fax: +49 (0) 3641 945 182.
E-mail address: christian.walther@uni-jena.de (C. Walther).

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faces as well (Fox, Oruc, & Barton, 2008; Hills, Elward, & Lewis, 2010; Hills & Lewis, 2012; Hole, 2011; Little et al., 2012; Walther et al., 2013). For example, Hills, Elward, and Lewis (2010) showed that following adaptation to the face of a famous identity 1, a face morphed between the famous identities 1 and 2 was more often perceived as identity 2, and vice versa following adaptation to identity 2. In this study, adaptation to artist-drawn caricatures induced the highest AEs, whereas adaptation to written names, voices, faces of associated identities, and imagined faces induced significant, but smaller AEs. These findings demonstrated that face identity AEs may not only depend on the temporal characteristics of the paradigm (Leopold et al., 2005; Rhodes et al., 2007), but also on the (physical) stimulus properties per se. Note however that other studies suggest a relative insensitivity of AEs to variations of other aspects of faces, such as changes of contrast, colour, or size (Yamashita et al., 2005), as well as of viewpoint, inversion, or vertical stretching (Hole, 2011).

The morphing technique (see, e.g., Benson & Perrett, 1991; Tiddeman, Burt, & Perrett, 2001) varies physical stimulus properties gradually, typically by creating a linear interpolation between a pair of face images. If the physical stimulus properties varied with morphing were the only factor determining our perception of these morphed faces, then this perception should follow a linear function as well. However, the categorical perception account (see, e.g., Beale & Keil, 1995; Rotshtein et al., 2005) on face identity processing has taught us that human perception of morphed faces does not seem to work on a merely linear basis. Morphing the face of a famous identity A to the face of another famous identity B does not result in a linear decrease of "identity A" responses over the morphing continuum, but a rather step-wise function with morph levels close to the original face of identity A yielding almost 100% identity A responses and morph levels close to identity B yielding almost 100% identity B responses, and only very few morph levels, in between A and B, yielding intermediate response proportions. Therefore, our perceptual system seems to treat most of the stimuli on such a morphing continuum as an *unambiguous* image of one or the other original identity, whereas only very few stimuli, typically from the middle of the continuum, seem to be treated as *ambiguous* with respect to facial identity. In the current study, we will use the term *(perceptual) ambiguity* to refer to this second stimulus-related factor also varied by morphing (see also Walther et al., 2013).

In a recent study (Walther et al., 2013), we investigated face identity AEs and repetition priming (PR) within the same stimulus repetition paradigm, keeping timing and task constant. Following the face of a famous identity (identity A, B, or C), an 50/50% morph between identities A and B, or a Fourier phase randomized (noise) stimulus, participants classified test faces varying on a morph continuum between identities A and B. Behaviourally, PR was reflected in a reduction of reaction times (RTs) for *unambiguous* target stimuli following identity-congruent adaptors, whereas AEs were observed both as contrastive biases in the perception of *ambiguous* target faces following identity A or B adaptors and in terms of peak shifts in the RT functions over the A–B continuum towards the adapted identity. Analyses of event-related potentials (ERPs) in this paradigm revealed a similar pattern: While neural correlates of PR were observed for *unambiguous* target stimuli, neural correlates of AEs were only found for *ambiguous* targets. As the same test stimuli never showed AEs and PR simultaneously, our results suggested a role of stimulus-related factors, such as the physical stimulus properties or their perceptual ambiguity, in determining which effect emerged.

In the context of the ongoing discussion on the contributions of high- and low-level processes to face identity AEs (see, e.g., Hills & Lewis, 2012; Rhodes et al., 2004), determining the contribution of physical stimulus properties and perceptual ambiguity to face identity AEs could be highly informative. However, studies on face identity AEs often entail a confound of both these stimulus-related factors, as both are varied by the morphing procedure simultaneously. In other words, changing the ambiguity of a test face invariably changes its physical stimulus properties as well. Although this confound hinders a clear separation of both factors, in another recent study from our lab (Walther, Schweinberger, & Kovács, 2013), we could demonstrate that both of these factors influence face identity AEs. In this study, adaptors varying gradually on a morphing continuum between faces of two famous identities A and B were followed by ambiguous 50/50% test faces, which had to be classified as either identity A or B. In general, the closer the adaptors were to one of the original identities the stronger the observed contrastive biases were. Interestingly, we also found that the data could be fitted by a combination of linear (as it would be expected if physical stimulus properties alone drove AEs) and higher-order polynomial functions, reflecting a rather step-wise shape of the curve (in line with a role of perceptual ambiguity for face identity AEs). Although this suggested a role of both the physical properties and the ambiguity of the stimuli as factors for face identity AEs, more specific conclusions about the role of ambiguity could not be drawn. Moreover, to our best knowledge, no previous study could unequivocally separate the influence of ambiguity from that of physical stimulus properties for face identity AEs.

Although a major proportion of the literature on face AEs seems to suggest that perceptual ambiguity is inevitably inherited from the physical properties of a stimulus (see, e.g., Webster et al., 2004), the following example shows that this does not have to be necessarily the case. In the perception of line tilt, a vertical line may be ambiguous when participants have to decide whether the presented line is tilted to the left or to the right, but the same line is unambiguous when a vertical/horizontal decision has to be made. In general, the specific task will determine the ambiguity of a stimulus. For the present study, we created a similar situation in face perception. To this end, we decided to manipulate perceptual ambiguity of the test stimuli in two ways, using a face identity adaptation paradigm similar to that of Walther et al. (2013). First, we created morphing continua spanning three different identities each (identity A to B to C, see Fig. 1 for an example) for our test stimuli, so that the test face, which is most ambiguous in an identity A versus C classification task, is not a 50/50% morph between identities A and C (as it is typically the case in studies on face identity AEs), but actually corresponds to the face of a different identity, B. Similarly, we also created a second morphing continuum, extending from B to C to D, therefore partially overlapping with the first, A–B–C continuum.

Furthermore, we manipulated the task context between two sessions, separated in time by at least 24 h. While in the first session, participants classified test stimuli drawn from an A–B–C continuum as either identity A or C, they classified test-stimuli drawn from an B–C–D continuum as either identity B or D in the second session. Similarly to the line tilt example, we hereby created a situation in which certain test faces were ambiguous in the one but unambiguous in the other session. For example, while identity B is ambiguous and C is unambiguous regarding the A versus C classification of the first session, identity B is unambiguous and identity C is ambiguous regarding the B versus D classification during the second session. We hypothesised that if perceptual ambiguity of the test stimuli plays a major role in determining face identity AEs, then the size of AEs for identities B and C should depend on the experimental session, or, in other words, on the classification task context. However, if the physical features of the stimuli are the only factor determining the magnitude of AE, then no such effect of the experimental task is expected. Indeed, the results of the present study revealed that AEs could be induced in both sessions, but always only for test stimuli that are