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A reflection on faces seen under mirror reversal

Jordan Suchow
Stevens Institute of Technology, New Jersey, United States

Malerie McDowell
University of Alabama at Birmingham School of Social and Behavioral Sciences, Georgia, United States

Jessica Huang and Jason Haberman
Rhodes College, Tennessee, United States

Abstract

Much of our visual experience of faces, including our own, is mediated by technology, for example when a digital photo depicts a mirror reversal of reality. How does this difference in visual experience affect judgments about appearance? Here, we asked participants to view their likeness in photographs that were reversed (as when viewed in a mirror) or not reversed (as when viewed directly). Observers also perceptually adapted (or not) to the reversed or non-reversed images in a 2×2 design. Observers then rated how much each photograph resembled them and how much they liked their appearance in the photograph, later repeating the procedure for images of close friends. We found that non-reversed images are perceived as more "unlike" one's self and less pleasant than reversed images; the pattern disappears when evaluating close friends, where the non-reversed image is the more familiar, with adaptation having asymmetric effects. Experiment 1A was fully replicated seven years later. These results are likely driven by a strong, albeit malleable, visual representation of self, born of technology mediated experience and activated when an unfamiliar perspective exposes facial asymmetries. We conclude by considering the downstream effects of these preferences on consumer and social behavior.

Keywords

face recognition, adaptation, social perception, aesthetics

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Corresponding author:
Jason Haberman, Rhodes College, 2000 N Parkway, Memphis, Tennessee, TN 38112, USA.
Email: habermanj@rhodes.edu

Much of our visual experience of faces is mediated by technology. First impressions of candidates for political office (Todorov et al., 2005), of prospective people to date (Degen & Kleeberg-Niepage, 2021; Ward, 2017), and of products to buy (Adil et al., 2018; Kanungo & Pang, 1973; Stewart & Furse, 1986) are often formed in response to photographs or videos of people, rather than in response to direct viewing of the people and the objects themselves. Many such photos are developed in the context of user-generated content on social media websites (Wyrwoll, 2014) and are often the primary means of exposure we have to the image of the depicted individuals (Bajaj & Sproull, 2003). Both individuals and organizations recognize the profound impact of photographic first impressions and use them to actively manage their reputation in a process of impression management (Leary & Kowalski, 1990; Lo & McKercher, 2015; Kaul et al., 2015; Ward, 2017).

Technology-mediated visual experience is prevalent not only with respect to the faces of others, but also with respect to our own face (Barbro, 2019; Lim, 2016; Murray, 2015). Because the orbits containing our eyes sit within the skull, direct visual experience of our own face is impossible.[1] Rather, we view our own image with the assistance of technologies such as mirrors, cameras, and portraiture, the advent of which led to the proliferation of technology-mediated self-experiences. Today, the average person has considerable visual experience of technology-mediated variants of their own appearance (Dhir, Pallesen, Torsheim, & Andreassen, 2016; Katz & Crocker, 2015), but none from the direct view available to everyone else.

The indirect views of the self afforded by reflections and depictions differ considerably from the direct view. For example, faces viewed in a mirror are reflected, preserving the presence of facial asymmetries but reversing their direction (Chaurasia & Goswami, 1975; Corballis, 2012; Thompson, 1943). Photographs of the self that are taken with cameras transform the input in ways that depend on the focal length of the lens, the resolution of the imaging sensor, post-processing applied to the resultant image, and other factors. And face-centric augmented reality (Bichlmeier et al., 2009) and photo-manipulation applications are centered around the transformation, distortion, and modification of personal imagery (Fu et al., 2010; van Dijck, 2008).

Here, we study the effect of technology-mediated perceptual experience on preferences and senses of familiarity for the self and close associates. In particular, we focus on the case of facial bilateral asymmetry (i.e., across the vertical meridian; Thiesen et al., 2015) because it provides a unique opportunity to study the effect of perceptual experience on judgments and preferences. This is because unlike Narcissus, who failed to recognize his own reflection, many today have grown so accustomed to the appearance of their face under mirror reflection that even a glimpse at a non-reversing mirror[2] is eerie (Mombaerts & Missotten, 2011; Watson, 1986). Continual exposure to reflections means that our primary self-image is a fiction. This provides the opportunity to design simple experimental interventions that use photographic manipulation to reveal to an individual their "true" self and then measure their subjective impressions of the same. We ask whether prolonged exposure to mirror reversals of their own appearance changes a person's self-image, causing them both to believe that those reversed images look more like them and to prefer them (see also Brady et al., 2005; Mita et al., 1977; Uddin et al., 2005). We also ask whether these effects are amplified by adaptation to mirror-reversed and non-reversed images and contrast the perceptions of self to those of others.

Differences in appearance can be amplified through *sensory adaptation*, a reduction in sensitivity to a stimulus that occurs after prolonged exposure to it (Jiang et al., 2006; Leopold et al., 2005; Webster & MacLeod, 2011). For example, in the waterfall effect, continual viewing of downward motion causes sensory adaptation that shifts the neutral point, such

that unmoving objects to appear to drift upward (Mather et al., 1998). Sensory adaptation applies to many visual properties, including motion, color, orientation, and shape (Clifford et al., 2007). Adaptation can be experimentally induced by asking a participant to view one image for a prolonged period (the "adapting stimulus") before making a decision about a second image (the "stimulus").

In the case of faces, adaptation causes the visual system to rapidly recalibrate in response to the faces it is exposed to (Watson & Clifford, 2003; Webster & Maclin, 1999; Zhao & Chubb, 2001), renormalizing face space so that it is more closely centered on the distribution of faces seen in visual experience (Rhodeset al., 2003). For example, with respect to judgments of facial aesthetics, adapting to laterally compressed or expanded faces shifts the perceived attractiveness toward the compression/expansion level of the adaptor; this is in part because average faces are considered more attractive and the shift changes what is perceived to be average (Rhodes et al., 2003).

In Experiment 1, we asked observers to view their likeness in target photographs that were reversed (as when viewed in a mirror) or not reversed (as when viewed directly). Additionally, before viewing the target photograph, observers viewed (or did not) the target photo in its reciprocal (reversed vs. original) form for a prolonged period, providing the opportunity for sensory adaptation. The adaptation period served to change the perceived image according to any facial asymmetries along the vertical meridian. The two factors (target photo reversal and presence of adaptation period) were varied in a 2×2 design. Observers then rated how much each photograph resembled them and how much they liked their appearance in the photograph.

In Experiment 2, we replicated Experiment 1 with new participants and added a within-participant manipulation: Participants arrived at the experiment with a partner whom they knew well and made two sets of judgments, the first using photos of the self and the second using photos of the partner. Given that others are only rarely seen in mirror reverse, and that the lateral asymmetries present in the appearance of familiar others is memorable (Rhodes, 1986), it is plausible that there is an interaction where mirror reversal has a different effect on judgments of the self versus of a partner.

Early evidence of this interaction can be found in both Mita et al. (1977), which studied the interaction in the context of the mere exposure effect (Bornstein, 1989; Zajonc, 1968), and in Cho & Schwarz (2010), which studied the interaction in the context of consumer preferences for fashion accessories. Mita et al. (1977) found that participants preferred the mirror reversal of their image over the true image 2:1, whereas their friends preferred the true image over the reversal 2:1, interpreting this as evidence of the mere exposure effect. Our study both conceptually replicates the empirical result of Mita et al. (1977) in our non-adapted preference-judgment condition and extends it in two important ways. First, the present study considers not only preference judgements in the context of the mere exposure effect, but also similarity judgments. Critically, these similarity judgments are key to impression and reputation management because they relate to whether a person believes that a photograph of them is adequately representative of the identity that they wish to convey. Second, we apply the manipulation of sensory adaptation, which can amplify perceptual effects and provide a cleaner demonstration that perceptual processing underlies the effect. In the case of consumer judgements, Cho & Schwarz (2010) found that consumers prefer fashion accessories displayed on the non-reversed (vs. mirror reversed) image of a familiar other individual, an effect attributed to a fluency advantage derived from the history of exposure to non-reversed images of familiar others; no effect was present when the other individual was unfamiliar (Cho & Schwarz, 2010). Our study differs from Cho & Schwarz (2010) in that we study judgments of faces, not products presented in the context of faces, and again include measures of both preference and similarity, critical for the aforementioned reasons.

Experiment 1A

Methods

Participants. Eighteen undergraduates from a U.S. Southern Liberal Arts College, ages 18 to 22, participated in this study for either course credit or monetary compensation at a rate of $10 per hour. All participants gave informed consent and had normal or corrected-to-normal vision. This research, and all research described herein, was approved by and conducted in accordance with the College's Institutional Review Board and APA ethical standards.

Stimuli and Design. Stimuli were digital images of the participant, obtained from a Logitech HD Pro Webcam C920 at 720×480 resolution in RGB color space. Participants were given no instruction regarding facial expression except to stare directly into the camera; most opted to smile. The background was a uniform off-white wall. All images were deleted after completion of the experimental session.

We asked observers to view their likeness in photographs in a 2×2 design: reversed (as when viewed in a mirror) or not reversed (as when viewed directly) and after adaptation to reversed/non-reversed image or after no adaptation (Figure 1, left). Images were displayed via a timed PowerPoint slideshow. In the no-adaptation condition, images (reversed or not reversed) were

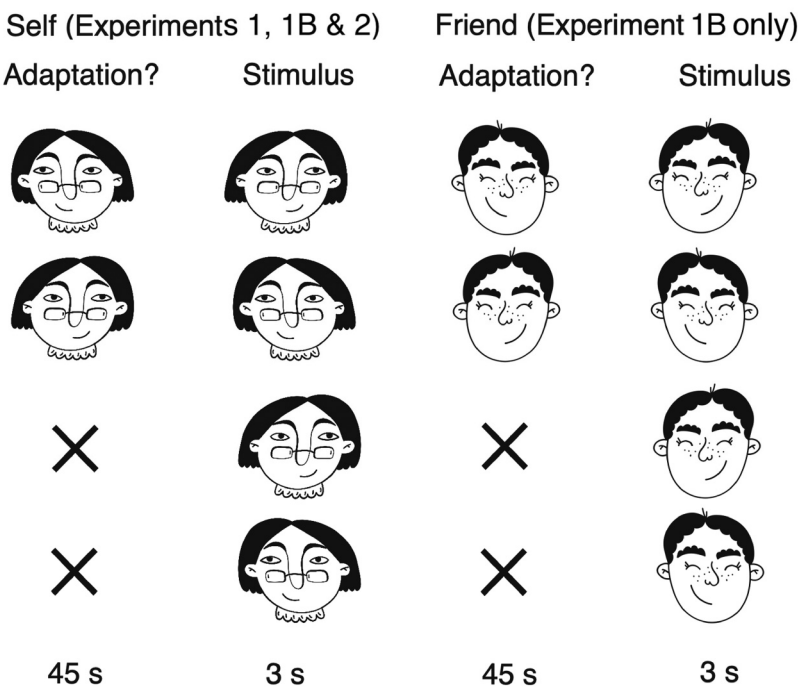

Figure 1. Schematic of the experiment design. Experiments 1 and 2 (left panel) manipulated two factors in a 2×2 design (first through fourth rows). The first factor was whether there was an adaptor presented before the stimulus (first and second rows) or there was no adaptor presented before the stimulus (third and fourth rows). The second factor was whether the stimulus (an image of the self) was presented in its non-reversed (first and third rows) or mirror reversed (second and fourth rows) form. Experiment 1B replicated Experiment 1 but added an additional factor for whether the adapting stimulus and main stimulus was an image of the self (same as Experiment 1, left panel) or was an image of a friend (right panel).

displayed for 3 s, followed by a prompt to respond to two questions: (1) "How much does this look like you?" and (2) "Do you like how you look here?" Images remained on screen until responses to both questions were received. In the adaptation condition, images were displayed for 45 s, followed by the converse of that image, also displayed for 3 s, before the response prompt finally appeared (e.g., having adapted to a mirror-reversed image, the participant would evaluate the non-reversed version of that image).

All data have been de-identified and uploaded to the Open Science Framework, along with scripts for analyses (anonymized link: https://osf.io/jrq6t/?view_only=e700cfad7b1d4585b1c04356ff8172db).

Procedure. Participants were seated 63 cm from the display. During adaptation trials, they were instructed to maintain fixation on the nose of the image. Participants rated how much each image looked like them and how much they liked the image on a scale of 1 ("Not at all") to 7 ("Very much"). Participants viewed each trial type 3 times for a total of 12 trials. Responses were averaged across trial types. The order of trial types was chosen randomly for each participant.

Results

Observers rated their reversed self (as in a mirror) as more similar to their appearance, even though this is not how others see them, as revealed by a 2 (reversal) × 2 (adaptation) repeated measures ANOVA performed on the first question (i.e., "How much does this look like you?"; $F(1, 17) = 14.17$, $p = .002$, $\eta_p^2 = 0.46$; see Figure 2A). The main effect of adaptation was also significant ($F(1, 17) = 8.65$, $p = .009$, $\eta_p^2 = 0.34$), suggesting that extended viewing of a face, reversed or non-reversed, prior to judging the oppositely arranged face reduces similarity ratings. The interaction between factors was not significant. As expected, the condition rated most similar was the one in which observers judged the mirror-reversed image without adaptation ($M = 6.3$), and the condition rated least similar was the one in which observers judged the non-reversed image after adaptation to the mirror-reversed image ($M = 5.39$).

The same pattern emerged for the second question regarding preference ("Do you like how you look here?"), as revealed by a separate 2 × 2 repeated measures ANOVA. Both the main effects of reversal ($F(1, 17) = 11.31$, $p = .004$, $\eta_p^2 = 0.40$) and adaptation ($F(1, 17) = 4.78$, $p = .04$, $\eta_p^2 = 0.22$) were significant, while the interaction was not. Overall, these results suggest that observers prefer

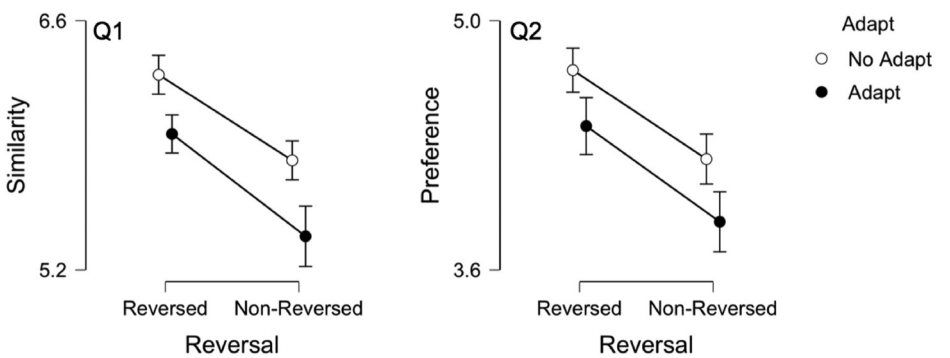

Figure 2. Results for Experiment 1A. Question 1 ("How much does this look like you?") and Question 2 ("Do you like how you look here?"). Error bars depict SEM.

viewing their own image in mirror-reversed form, and view that image as more similar to their internal representation of their own face.

It is worth noting that these effects emerged despite potential ceiling effects. All the images, mirror reversed or not, in fact depict the person examining them, and so one might have thought that every rating of similarity would be reported as 7 on a 7-point scale. However, ratings of the non-reversed image were reduced relative to the reversed image, and this effect was enhanced after adaptation to the reversed image. Thus, our measure suggests a robust internal representation of self—one that is sensitive to subtle, disruptive changes. This representation is driven by what is most familiar, which, for most individuals, is the mirror-reversed image.

Experiment 1B

Methods

In Experiment 1B, we repeated the experiment, replicating the original design exactly in a new sample of observers ($N = 18$), while also asking those observers to judge photographs of people familiar to them (Figure 1). Each participant arrived at the study with a friend, such that each member of the pair knew the other's face well. Participants were recruited from the local participant pool using the following language: "This experiment requires two people who know each other fairly well and spend time together frequently. This can be friends, roommates, significant others, or close classmates."

Participants. Eighteen Rhodes College undergraduates, ages 18 to 22, participated in this study for either course credit or monetary compensation. Two participants were removed from analysis due to scripting errors and another due to responding with only one value for the duration of the experiment. The compensation rate was $10 per hour. All participants gave informed consent and had normal or corrected-to-normal vision.

Stimuli and Design. The stimuli and experiment design were identical to that of Experiment 1A, except that participants made two sets of judgments, one with respect to images of the self, the other with respect to images of their friend. Stimuli were presented on a 27″ Dell display controlled by the Psychophysics Toolbox (Brainard, 1997; Pelli, 1997), a software package often used in vision science for precise control of stimulus presentation, using MATLAB (Natick, MA), a numerical computing environment that the Psychophysics Toolbox is built upon.

Procedure. The procedure matched that of Experiment 1A, with the addition of a second, interleaved condition for judgments made with respect to images of a friend, for a total of 24 trials.

Results

The results of Experiment 1B closely matched the results of Experiment 1A. Observers again preferred their reversed self (as in a mirror) to any other condition, as revealed by a 2×2 repeated measures ANOVA performed on the first question (i.e., "How much does this look like you?"; $F(1, 14) = 9.76$, $p = .007$, $\eta_p^2 = 0.41$; see Figure 3). The main effect of adaptation was also once again significant ($F(1,14) = 14.29$, $p = .002$, $\eta_p^2 = 0.51$), as was the interaction ($F(1, 14) = 13.18$, $p = .02$, $\eta_p^2 = 0.49$) suggesting that adaptation had a larger impact when judging the non-reversed image than the reversed image (recall that when judging the non-reversed image in an adaptation trial observers are exposed to the reversed image for 45 s beforehand; see Figure 3 top left panel).

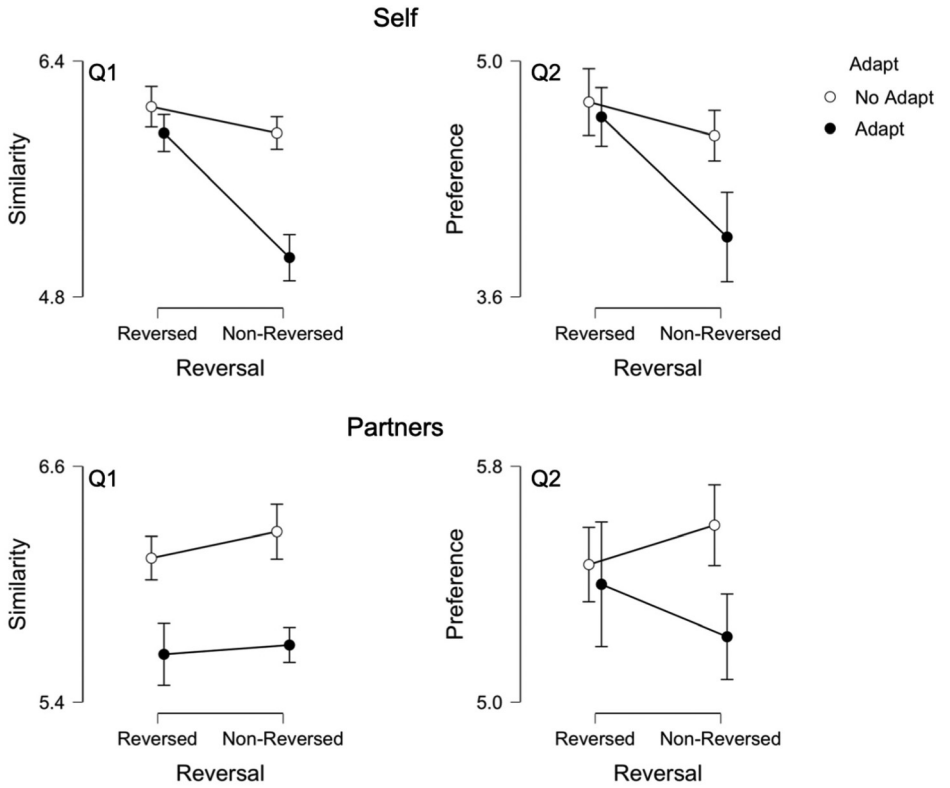

Figure 3. Results for Experiment 1B. Top. Questions 1–2 regarding self. Bottom. Questions 1–2 regarding partner. Error bars depict SEM.

A similar pattern emerged for the second question ("Do you like how you look here?"), as revealed by a separate 2×2 repeated measures ANOVA, although the main effect of reversal was not significant ($p = .13$). Both the main effect of adaptation and the interaction between reversal and adaptation were marginally significant ($F(1, 14) = 4.48$, $p = .05$, $\eta_p^2 = 0.24$; $F(1, 14) = 4.22$, $p = .06$, $\eta_p^2 = 0.23$, respectively; Figure 3 top right panel).

Judgment of the familiar faces of friends showed a qualitatively distinct pattern from judgment of self (Figure 3 bottom panels). Observers no longer thought the reversed images most resembled their friends, likely because most of their experience of their friends' faces is mediated through direct viewing (non-reversed). Although only the main effect of adaptation reached significance ($F(1, 14) = 12.02$, $p = .004$, $\eta_p^2 = 0.46$), and no effect was significant for the second question (preference), the overall pattern supported our original hypothesis. Clearly, the conditions under which observers are exposed to their own faces are different from those conditions when they view other peoples' faces. The particulars of those conditions (e.g., mostly mirror viewing vs. mostly direct viewing) result in meaningfully different self versus other representations.

Experiment 2

Since data collection from the first two experiments, which occurred in 2016–2017, the use of self-image applications (e.g., Zoom, Tik Tok) has vastly increased, providing additional potential exposure to non-reversed images of one's own face. While our initial findings revealed a strong

preference for one's own reversed face, these effects may have been mitigated by the use of such technologies. In Experiment 2, we replicate Experiment 1A six years later, offering a perspective on the mutability of self-representation.

Methods

Participants. Thirty undergraduates (13 M, 13 F, 4 non-binary; average age = 18.6) participated in this study for course credit. This sample size was pre-determined by a power analysis run in g*power (Faul et al., 2007) to achieve a medium effect size of 0.3. All participants gave informed consent and had normal or corrected-to-normal vision.

Stimuli and Design. Stimuli and design were nearly identical to Experiment 1. In this version, the experimental session was implemented in Matlab using Psychophysics Toolbox, as was the case for Experiment 1B.

Procedure. Procedure was identical to Experiment 1.

Results and Discussion

Results replicated our original finding—participants rated their mirror-reversed selves as more similar to how they appear than their non-reversed selves (Q1; $F(1, 29) = 5.85$, $p = .022$, $\eta_p^2 = 0.17$); the same was true for their preference ratings (Q2; $F(1, 29) = 5.09$, $p = .03$, $\eta_p^2 = 0.11$). There was an effect of adaptation for their similarity ratings (Q1; $F(1, 29) = 6.09$, $p = .02$, $\eta_p^2 = 0.17$), driven by the reduction in ratings for non-reversed images following adaptation to mirror reversal. However, the effect of adaptation was not significant for preference ratings (Q2; $p = .19$). While the overall effect size was smaller in this experiment, the grand means did not differ from data collected in Experiment 1, as determined by a mixed-effects ANOVA with year of data collection as the between-subjects factor ($F(1, 46) = 2.57$, $p = .12$, $\eta_p^2 = 0.04$). These results suggest that, while individuals likely have had greater exposure to their non-reversed selves through various forms of social media, this exposure has not mitigated their overall similarity ratings or preference for the self displayed in mirror reversal (see Figure 4).

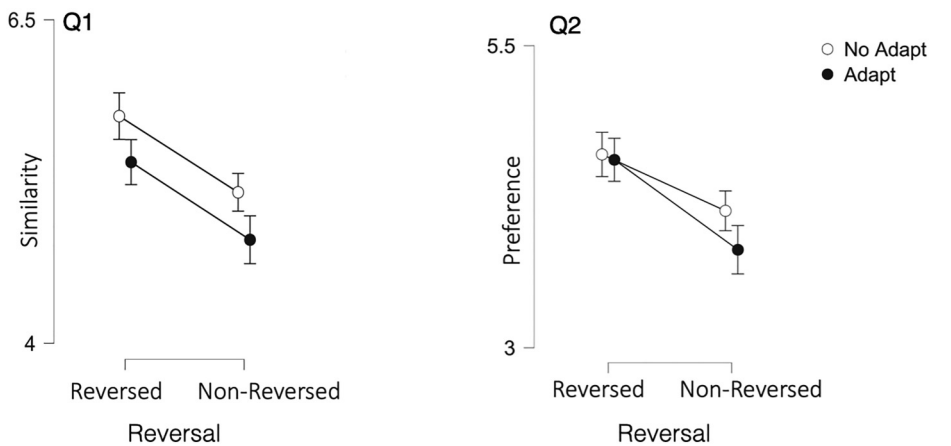

Figure 4. Results for Experiment 2, which was a replication of Experiment 1A. Error bars depict SEM.

General Discussion

Technology mediated experiences with faces cause the indirect visual experience of our own face to systematically differ from the direct view afforded to others. These differences in experience may give rise to differences in perception and preference with respect to our appearance, differences that can be measured through laboratory experiments and amplified by perceptual adaptation.

Here, through three experiments in which participants judged images of the self, we found that adaptation amplified a predisposition towards finding the reversed image (as in a mirror) to be both a better likeness and preferable to the non-reversed image (as in a depiction). In contrast, when participants made these same judgments about photographs of friends, the amplification bias for mirror reversed images effectively vanished. The preference result in the non-adapted condition provides a conceptual replication of the empirical result of Mita et al. (1977).

These results are likely driven by a strong, albeit malleable, representation of self, one created by most often viewing ourselves in a mirror. Non-reversed images are perceived as more "unlike" one's self and less pleasant than reversed images because they expose facial asymmetries with which viewers are unfamiliar given their visual experience. This general pattern disappears when evaluating images of close friends, since the non-reversed image is the more familiar one. Interestingly, adapting to the reversed partner image significantly reduced the judgments of the non-reversed (more familiar) partner image, suggesting the representation of others may be more malleable than the representation of self.

Under this conception of a malleable representation of appearance, the relative balance of depictions or reflections versus direct viewing in a person's visual experience determines the pattern of a person's judgments and preferences with respect to mirror reversals. The pattern may shift over time as a person's experiences change, or differ across people with different experiences. For example, a woods-dwelling hermit with little-to-no exposure to faces would have little basis for distinguishing between a reversed and non-reversed image. In contrast, a person who delights in self-portraiture might grow accustomed to their non-reversed faced and come to prefer it, although our most recent data do not support this notion. Perhaps, with the use of consumer-grade digital cameras and their continued incorporation into mobile phones, combined with video conferencing application usage, the prevalence of portraiture will increase to such a degree that able people will become more accustomed to non-reversed images of themselves (Rubinstein & Sluis, 2008). Our results might also help to explain prevalent findings showing individuals choose pictures for social media profiles and dating applications that do not optimally represent how others view them (White et al., 2016; White et al., 2017). Perhaps people are most likely to select images that resemble their mirror-reversed selves, which is not how the rest of the world views them. When given the opportunity, it might be a better strategy for people to let other individuals select which image to use for their profile, as opposed to self-selection.

Individuals and organizations use photographs to actively manage their conveyed impressions, which can shape later interpersonal relationships and consumer behavior (Kaul et al., 2015; Leary & Kowalski, 1990; Lo & McKercher, 2015; Ward, 2017). Impression and reputation management often involve the crafting and selection of images and messages believed to impart the desired impression to a consumer or other observer. Similarity and representativeness judgments are thus key to impression and reputation management because they relate to whether a person believes that a photograph of them adequately represents of the identity that they wish to convey. Here, we found that participants perceived mirror-reversed photographs to better represent their own appearance. Our results therefore point to an important asymmetry present in all cases of reputation and identity management: a person or organization may wrongly reject an image or message under the illusory impression that it does not adequately represent them, said false impression being a byproduct of the person or organization's own distorted self-image. Though clear enough in the

case of mirror-reversed photographs, further research is needed to understand how this dynamic plays out with respect to more abstract dimensions related to individual and brand identity and appearance, such as perceived trustworthiness or credibility.

Finally, let us not forget Narcissus, who, having fixated on his reflection long enough to produce adaptation in the extreme, should perhaps be rather grateful for having only withered into a flower. For had he been granted the misfortune of then seeing his true, non-reflected self, our results suggest he would likely have faced a fate worse than death.

Author Contributions

Jordan Suchow: Conceptualization; Investigation; Methodology; Supervision; Writing – original draft; Writing – review & editing.
Malerie McDowell: Data curation; Formal analysis; Methodology; Project administration; Validation; Visualization; Writing – original draft.
Jessica Huang: Data curation; Methodology; Project administration; Visualization.
Jason Haberman: Conceptualization; Data curation; Investigation; Methodology; Project administration; Resources; Software; Supervision; Validation; Visualization; Writing – original draft; Writing – review & editing.

Declaration of Conflicting Interests

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ORCID iD

Jason Haberman https://orcid.org/0000-0002-9578-0593

Notes

1. This is not entirely true. For most people, a fair bit of the nose is visible. Its continual presence in the visual field has the curious side effect of it receding from conscious awareness. Even the most self-aware painters intent on capturing their subjective visual experience tend not to include their own nose when painting portraits, still life, or landscapes.
2. A non-reversing mirror is a pair of angled mirror panels set up in such a way that they reflect the image, but do not reverse it, matching what others see.

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