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Inverting an Image Does Not Improve Drawing Accuracy

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It has been suggested that inverting an image will increase drawing accuracy. However, perceptual evidence suggests that inverting an image inhibits processing of spatial information. D. J. Cohen and S. Bennett (1997) theorized that perceptual distortions will lead to drawing errors. In the present experiment, the authors test whether inverting an image improves drawing accuracy, as suggested by art educators, or results in distorted drawings, as predicted by Cohen and Bennett. The present data reveal that inverting an image inhibits the drawing accuracy of spatial relations thus supporting Cohen and Bennett's (1997) theory of drawing accuracy.

Keywords: drawing, inversion, face recognition, art, portraits

Some have argued that interfering with the canonical perception of a stimulus will inhibit the automatic perceptual processes that lead to the misperception of a stimulus and, as a result, will increase drawing accuracy (Edwards, 1986, 1989). Perhaps the most commonly suggested method for interfering with the canonical perception of a stimulus, thus leading to more accurate drawings, is to invert the stimulus (e.g., Brookes, 1991; Garcia, 2003; Hoddinott, 2003; Parks, 2003). For example, Ruskin's Innocent Eye hypothesis posits that object recognition interferes with the accurate perception of shape (see Rosenberg, 1963).[1] Those advocating inversion often accept a version of Ruskin's Innocent Eye hypothesis and suggest that inverting an image interferes with the recognition process, allowing the artist to achieve a "purer" perception of the shapes that compose the stimulus and thus to draw the stimulus more accurately (e.g., Edwards, 1989; Parks, 2003). The popularity of the inversion suggestion can be seen by searching for "drawing tips" on the Internet. Although inversion has been shown to cause a change in perception, this change may not facilitate drawing accuracy. In the present article, we review the effects of inversion on perception and present an experiment that assesses the effects of inversion on drawing accuracy.

Evidence has accumulated that suggests that the major cause of adult drawing inaccuracies have their foundation in the artist's perception of the to-be-drawn stimulus (Cohen, 2005; Cohen & Bennett, 1997; Cohen & Jones, 2008; Kozbelt, 2001; Lee, 1989; Mitchell, Ropar, Ackroyd, & Rajendran, 2005). In an effort to assess the chief source of drawing inaccuracies, Cohen and Bennett (1997) decomposed the drawing process into four stages: perceiving the to-be-drawn stimulus, deciding where and how to make a mark, the motor ability required to make said marks, and evaluating one's own drawing. Although each of the stages may play a small role in drawing inaccuracies, Cohen and Bennett ruled out the latter three stages as major sources of drawing inaccuracies. They concluded that the first stage of the drawing process (perception of the to-be-drawn stimulus) was the most likely source of major drawing inaccuracies. Thus, if Cohen and Bennett's hypothesis is correct, any transformation of a stimulus that causes a change in the artist's perception of that stimulus should be apparent in the drawing of the artist.

It has been shown that any deviation from a form's canonical orientation can cause a change in perception (Cohen & Blair, 1998; Cohen & Kubovy, 1993; Rock, 1974; Shepard & Metzler, 1971). Inversion has been shown to interrupt the processing of spatial information while having little effect on the processing of featural information (Boutsen & Humphreys, 2003; Cabeza & Kato, 2000; Farah, Tanaka, & Drain, 1995; Farah, Wilson, Drain, & Tanaka, 1998; Koriat & Norman, 1989; Leder & Bruce, 2000; Tanaka & Farah, 1993; Tanaka & Sengco, 1997). *Spatial* processing refers to the accurate processing of the relative positions of the constituent parts or features, whereas *featural* processing refers to the accurate processing of the shape of the constituent parts or features (Cabeza & Kato, 2000; Leder & Bruce, 2000; Tanaka & Farah, 1993).

The inhibition of spatial processing because of inversion has been widely documented in facial recognition research (Diamond & Carey, 1986; Farah et al., 1995; Farah et al., 1998; Gauthier & Tarr, 1997; Tanaka & Farah, 1993; Tanaka & Sengco, 1997). It has been shown that, when a face is inverted, the processing of the spatial relations between features is inhibited, whereas the processing of the local features is not (Leder & Bruce, 1998; Murray, Young, & Rhodes, 2000; Searcy & Bartlett, 1996; Tanaka & Sengco, 1997). Farah et al. (1995) studied this effect by presenting subjects with whole faces as well as individual facial features. Inversion had a pronounced detrimental effect on the recognition of the whole faces but little to no effect on the recognition of individual facial features.

Although artists and educators espouse the benefits of inverting stimuli to aid drawing, the perceptual evidence suggests that stim-

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[1] Gombrich (1960) criticized the innocent eye hypothesis, stating that one can never inhibit the brain's automatic recognition and classification processes.

ulus inversion will inhibit the perception of spatial relations. Thus, if Cohen and Bennett's (1997) theory is accurate, and the perception of the to-be-drawn stimulus is the major source of drawing errors, then perceptual distortions should be evident in one's drawing. As a result, Cohen and Bennett's (1997) theory predicts that the loss of spatial processing that occurs with inversion will inhibit drawing accuracy for the spatial relations while not affecting drawing accuracy for featural information. In the present experiment, we asked both novice and trained artists to draw a photograph of a face. For half the participants, the photograph was presented in its canonical orientation; for the remaining participants, the photograph was inverted. The final renderings were judged on their drawing accuracy for featural, spatial, and overall information. Faces were chosen because (a) there exist extensive data describing the influence of inversion on the perception of the spatial and featural components of faces (as discussed earlier), (b) the importance of portraiture in art history, and (c) the specific references to inverting faces in the "how-to-draw" literature (e.g., Edwards, 1989). If inversion increases drawing accuracy, then those participants in the inverted conditions would have higher drawing accuracy ratings than those in the upright condition. In contrast, if drawing errors are a function of perception, then inversion should negatively affect the drawing accuracy of spatial information while having little or no effect on the drawing accuracy of featural information.

Method

Participants

One hundred twenty-one students volunteered as participants. The participants were grouped according to their artistic background, either novice or expert. The 72 novice participants were students enrolled in introductory psychology classes, who were recruited through a posted sign-up sheet, and they received course credit for their participation. The 49 expert participants were studio art majors and minors who were recruited from various studio classes, and they received extra credit for participating. Each participant was assigned to a condition, either upright or inverted, which were counterbalanced between participants.

In addition, four critics were used to assess drawing accuracy. The critics consisted of two professors of art history and two professors of studio art at the University of North Carolina Wilmington.

Stimuli and Materials

Drawing task stimuli. Eight grayscale photographs were used in the drawing task. Each photograph depicted the head and shoulders of an approximately 20-year-old Caucasian female, with no distinguishing facial features or marks such as eyeglasses or birthmarks. The females and photographs were selected because they were similar with respect to age, race, weight, and pose (see Figure 1). Each photograph was 17.1 × 26 cm, and the backgrounds were digitally removed.[2]

Black foam board was used to make a structure that was 92.7 cm wide × 76.2 cm tall and placed 58.4 cm from the edge of the table. Two hooks, placed on the foam board, were used to hang the photographs in the center of the board. The photograph was mounted approximately 63.5 cm in front of the participant and 24.5 cm above the tabletop.

Figure 1. The eight original photographs used in the experiment.

Rating task stimuli. Three rating standards were created for each of the original photographs: a featural rating standard, a spatial rating standard, and an overall rating standard. These standards were used in the judging process and consisted only of the information necessary to make the specific rating. The featural rating standards were created to remove all spatial information but retain the shape of the features. To create the featural rating standard for each face, the left eye, nose, and mouth were isolated from the corresponding photograph and embedded horizontally in a plain white document. The spatial rating standards were created to remove all featural information but retain the spatial placement of the features. To accomplish this for each face, we created a gray oval the size of the face. Two small black ovals were then positioned where the eyes were located, a vertical rectangle was placed where the nose was located, and a horizontal rectangle was placed where the mouth was located. The overall rating standard contained the corresponding original photograph. An example of the featural, spatial, and overall rating standards can be seen in Figure 2.

Procedure

Each participant was tested individually. The position of photograph (upright or inverted) was counterbalanced between participants, and each participant was randomly assigned a photograph to be drawn. The participants were given a blank sheet of white paper (21.6 cm × 27.9 cm) and instructed that they had 10 min to complete the drawing of a face. They were instructed to draw the picture exactly as they saw it, use the full 10 min, and draw to the best of their ability. The assigned photograph was then mounted either upright or inverted, depending on the assigned condition, and the participants had 10 min to complete their drawing, which was timed by the experimenter with a stopwatch. When the 10 min had elapsed, the participant was instructed to discontinue drawing.

For the judging process, all the drawings were divided according to the photograph drawn and placed into corresponding folders, forming eight folders. All renderings and photographs were in their upright orientation for judging. The order of the renderings in each of the folders was randomized before obtaining the critics' ratings.

[2] No pretesting was conducted on the stimuli.

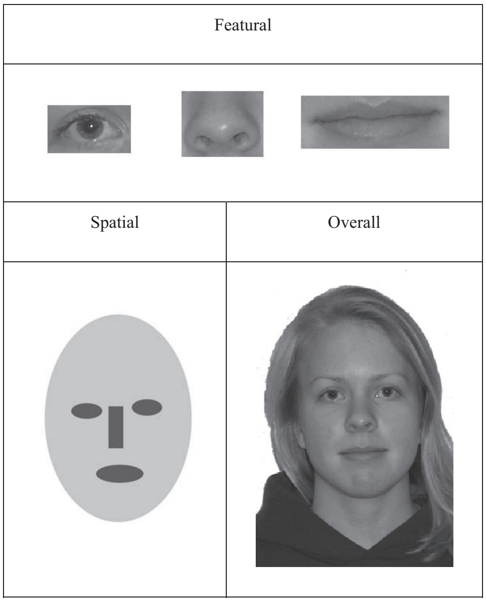

Figure 2. Example of featural, spatial, and overall images provided to the critics.

Each drawing was given three accuracy ratings by the each of the critics: one based on the featural details, one based on the spatial details, and one for overall accuracy of the drawing. Instructions were given to each judge describing featural details as those based on the parts of the face such as the nose, mouth, and so forth, and spatial details as the relationships between the features of the face. When judging the accuracy of renderings, the critics were presented the relevant images of the face the artists drew to compare to the artists' renderings of the face. That is, when making their featural drawing accuracy ratings, critics were presented the featural ratings standards to compare with the artists renderings. When making their spatial drawing accuracy ratings, critics were presented the spatial ratings standards to compare with the artists renderings. When making their overall drawing accuracy ratings, critics were presented the original photograph of the drawn face to compare with the artists renderings.

Critics were asked to rate the accuracy of the drawings on a scale ranging from 1 (*a very poor representation*) to 100 (*a very accurate representation*). All rating documents had a copy of the rating scale on the bottom. The critics viewed the entire set of drawings three times: once for each rating. The order was fixed to control for the critics knowledge of the overall composition of each face: featural, spatial, and overall.[3]

In summary, first the critics rated each drawing on its featural accuracy using the featural rating standards as their standards of comparison. When the critics completed their ratings of all the drawings on featural accuracy, they rated each drawing on its spatial accuracy using the spatial rating standards as their standards of comparison. Finally, when the critics completed their ratings of all the drawings on spatial accuracy, they rated each drawing on its overall accuracy using the original photographs as their standards of comparison. The order of drawings was randomized between the critics. Each rating was given by the critic at his or her own pace, aloud, and the researcher recorded the response.

Results

To ensure consistent use of the rating scale between critics, we standardized each critic's ratings to have a mean of 0 and an *SD* of 1. These standardized ratings were used in all analyses. Cronbach's alpha, $\alpha = 0.797$, showed that the critics' ratings were reliable given the subjective nature of the task. Cronbach's alphas ranged from 0.73 for spatial ratings to 0.83 for featural ratings. Figure 3 presents example drawings, showing the range of drawing accuracies produced in the present study as measured by the critics' overall ratings.

We calculated a 2 (skill) $\times$ 2 (photograph orientation) $\times$ 4 (critic) mixed-model analysis of variance (ANOVA) on the featural, spatial, and overall ratings, with photograph and artist entered as random effects. From an abundance of caution, we included critics in the analysis to identify whether specific critic biases influenced the effects of interest. Results showed a significant main effect of skill on the featural, $F(1, 117) = 69.0$, $p < .01$; spatial, $F(1, 117) = 42.6$, $p < .01$; and overall ratings, $F(1, 117) = 35.4$, $p < .01$. Artists outperformed nonartists on all three rating types (see Table 1). There was also a Skill $\times$ Rater interaction on the spatial, $F(3, 351) = 5.3$, $p < .01$; and overall ratings, $F(3, 351) = 3.6$, $p = .01$. To explore these interactions, we conducted simple main effects by critic on skill level. For both spatial and overall ratings, all critics rated the trained artists' drawings as more accurate than the novice artists' drawings (all Fs > 4.0, ps $< .05$). Thus, each individual critic's ratings were consistent with the identified main effect of skill.

There was an effect of the orientation of the photograph only on the spatial ratings, $F(1, 117) = 4.05$, $p < .05$. Participants were rated lower for drawing spatial details when the photograph was inverted ($M = -0.11$, $SD = 0.73$) than when the stimulus was upright ($M = 0.11$, $SD = 0.72$). There was no significant effect of orientation on featural ratings, $F(1, 117) = 2.66$, *ns*; or overall ratings, $F(1, 117) = 1.11$, *ns*. There were no significant interactions (Fs < 2.0).

Given the significant effect of orientation on spatial ratings, one would generally expect a similar effect on overall ratings. Although the mean differences were in the predicted direction, (for upright, $M = 0.065$, $SD = 1.0$; for upside down, $M = -0.064$, $SD = 0.95$), the difference did not reach significance, $F(1, 117) = 1.11$, $p = .29$. This suggests that the critics' judgments of overall accuracy are not the simple addition of spatial and featural ratings.

Discussion

It has been suggested that inverting a to-be-drawn stimulus will result in increased drawing accuracy (Edwards, 1986, 1989). The data from the present experiment show that inversion does not increase overall drawing accuracy of portraits. Rather, inversion decreases the drawing accuracy of spatial relations.

The findings of the present experiment are consistent with both Cohen and Bennett's (1997) theory of drawing accuracy and the

[3] Because the standard of comparison for the overall rating is the original photograph, it contains both spatial and featural information. By presenting this image last, we can assure that the initial estimates of spatial and featural accuracy are not biased by any knowledge gleaned from the original photograph.

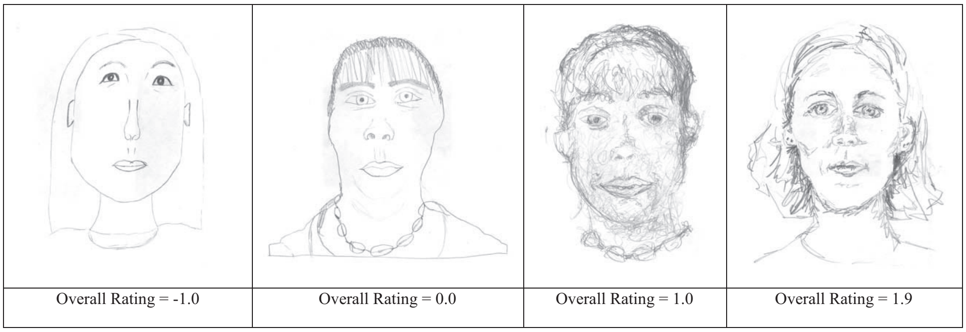

Figure 3. Example drawings showing the range of drawing accuracies as measured by the critics' overall ratings. The overall ratings of the entire set of drawings ranged from −1.22 to 2.33.

extant literature examining the perception of inverted images. Specifically, Cohen and Bennett (1997) theorized that the major source of adult drawing errors has its foundation in the artist's perception of the to-be-drawn stimulus. Researchers have demonstrated that inversion distorts one's perception of a face by inhibiting spatial processing while having little or no effect on featural processing (e.g., Farah et al., 1995; Tanaka & Farah, 1993; Leder & Bruce, 2000). Therefore, if Cohen and Bennett's theory is correct, inverting a photograph of a face should result in decreased ability to accurately render spatial relations while having little or no effect on the rendering of featural information. This is exactly what our data showed.

It is interesting that inversion of faces negatively affected the drawing accuracy for spatial information of both novice and trained artists. The lack of a significant interaction between skill and inversion on any dependent measure of accuracy suggests that training does not mitigate the degree of influence that perceptual distortion has on drawing accuracy. This finding is interesting, because researchers have demonstrated that artists often have superior visual cognition skills (e.g., Cohen & Jones, 2008; Kozbelt, 2001). In contrast to the present findings, Cohen and Jones (2008) have demonstrated that artists can overcome the effects of shape constancy. The presence of these two disassociated distorting perceptual effects (the effects of inversion and shape constancy) provide clues to the source of drawing errors. That is, artists cannot overcome all distorting perceptual effects. Identifying those that can be overcome (and those that cannot) will likely lead to a better understanding of the source of drawing errors.

These findings have some implications for art education. Specifically, the data further support the theory that perceptual distortions are a source of drawing errors. Therefore, techniques that teach students to overcome the effects of perceptual distortion are likely to increase drawing accuracy. These techniques, however, should focus on those distorting effects that artists have the ability to overcome, such as shape constancy. Those that even experts do not overcome, such as the effects of inversion, may provide little benefit to potential future artists.

The present experiment is limited to the role of inversion of faces on drawing accuracy. There is evidence that suggests that the perception of spatial relations is particularly important when viewing objects with which one is very familiar, such as faces (Diamond & Carey, 1986). For less familiar objects, viewers rely more on featural processing than spatial processing. As such, the decrement in drawing accuracy may not generalize to the same degree for less familiar stimuli, such as houses. Nevertheless, because our data showed no increase in the drawing accuracy of featural relations, and because, although less important, spatial relations are not ignored for less familiar objects (e.g., Farah et al., 1998), we predict no benefit to inversion for less familiar objects.

In summary, the present experiment assessed the conventional wisdom that inverting an image increases drawing accuracy. Our data showed that inverting a face inhibits the drawing accuracy of spatial relations of the stimulus. This finding is predicted by Cohen and Bennett's (1997) theory of drawing accuracy in combination with the perceptual evidence on image inversion. In addition, this finding emphasizes the need for empirical support for the popular claims of art educators.

Table 1
Means and Standard Deviations of Featural, Spatial, and Overall Ratings of the Accuracy of the Drawings by Skill

	Featural		Spatial		Overall	
Skill	*M*	*SD*	*M*	*SD*	*M*	*SD*
Artist	0.5936	0.7001	0.5282	0.6612	0.4704	0.7892
Nonartist	−0.4039	0.6172	−0.3595	0.7462	−0.3201	0.6643

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