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Face Inversion Impairs the Ability to Draw Long-Range, but Not Short-Range, Spatial Relationships Between Features

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Abstract

Art instructors have promoted the idea that reproducing upside-down models facilitates drawing accuracy. However, perceptual research has demonstrated that face inversion impairs the perception of long-range and, to a lesser extent, short-range spatial relationships between features. This suggests that drawing an upside-down face model might impair, rather than facilitate, drawing performance with respect to the accuracy of depicting the spatial relationships between features. In this study, participants drew an upright and upside-down face. Participants were less accurate in drawing the long-range spatial relationship between the eyes and mouth when drawing the upside-down face than when drawing the upright face. In contrast, they were equally accurate in drawing the short-range spatial relationships between the (a) eyes and eyebrows, (b) nose and mouth, and (c) two eyes when drawing the upright and upside-down models. This result fails to empirically validate the effectiveness of drawing models upside-down for the purposes of facilitating drawing accuracy.

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Observational drawing is the behavior where individuals attempt to draw a recognizable depiction of a directly perceived model. Many individuals without a lot experience or training in drawing experience difficulty in producing high-quality drawings of this type. Therefore, one goal of art education has been to develop instructional strategies that aim to increase the accuracy of students' observational drawings. One such strategy, famously promoted by Edwards (2012), is the practice of drawing models upside-down to increase novices' drawing accuracy. The theoretical foundation of the practice is based on the idea that

> [novices] do not perceive in the special way required for drawing. They take note of what's there, and quickly translate the perception into words and symbols mainly based on the symbol system developed throughout childhood and on what they know about the perceived object. (Edwards, 2012, p. 82)

In other words, most novices' drawings are theorized to partially be reproductions of graphic symbols stored in memory that *stand for* the elements of an object (e.g., a smile as a U-shaped line; the eyes as isolated circles or ovals; the shape of the head as a circle) rather than the apparent visual information contained in the model stimulus. Further, Edwards theorized that perceiving objects in noncanonical orientations (e.g., upside-down) inhibits the activation of such symbolic representations and therefore facilitates the ability of individuals to accurately perceive, and therefore draw, the visual information inherent in the model. This theoretical foundation and the resulting practice became very well known in the art-instruction field, as evident by the widespread advocating of this technique on many online drawing tutorials (perform a Google search using the term *upside-down drawing*), in many print-based drawing manuals (e.g., Garcia, 2003; Parks, 2003), and in drawing classes.

Even though there is much anecdotal and testimonial evidence that suggests this technique is effective, this claim did not receive any formal scientific test of its effectiveness for over 30 years until the study reported by Cohen and Earls (2010). They assessed how performance was affected by drawing from an upside model of a face because the misperception theory of drawing accuracy (Cohen & Bennett, 1997) predicted that certain elements of drawing performance should be impaired, rather than improved, when drawing an upside-down face. It has long been known that upside-down faces are more difficult to recognize than upright faces (Yin, 1969). This impairment is not related to the visual processing of all information contained in a face. Rather, while there is some evidence to suggest that the recognition of individual facial features are not affected by face inversion, individuals are less sensitive in perceiving the spatial relationships between facial features when faces are upside-down than when they are upright (Leder & Bruce, 1998, 2000; but see McKone & Yovel, 2009 for a discussion of the inconsistences in the literature pertaining to the issue of whether the recognition of individual features is or is not affected by face inversion). The misperception hypothesis of drawing accuracy proposes that any process that results in a perceptual error of a stimulus should additionally result in a similar drawing error of that stimulus. This leads to the prediction that, relative to drawing upright-oriented faces, drawing upside-down faces should cause a reduction in the accuracy of reproducing the spatial relationships between facial features but should not affect the accuracy of reproducing the appearance of the individual features themselves.

Cohen and Earls (2010) tested this prediction in an experiment where participants were randomly assigned to draw an upright or upside-down face. The drawings were later subjectively rated for perceived accuracy by independent judges with respect to two separate aspects of the drawings: (a) the reproduction of the individual local facial features and (b) the spatial positioning of the facial features relative to one another. They reported that the accuracy ratings pertaining to the spatial positioning of features were lower for drawings of upside-down faces compared with upright faces but that there was no difference between the upright and upside-down drawings with respect to their local-feature accuracy ratings. Thus, the results provided empirical support of the misperception hypothesis while simultaneously disconfirming the anecdotally reported effectiveness of the practice of drawing models upside-down (at least with respect to face models).

One question that is raised by these results is whether face inversion causes all or only some of the spatial relationships between facial features to be drawn with poorer accuracy. If perceptual inaccuracies cause similar drawing inaccuracies, as asserted by the misperception hypothesis, then one would predict that face inversion should impair the drawing accuracy of some spatial relationships in a face more than others. This is because face inversion impairs the ability to visually perceive some spatial relationships between features more than others. Specifically, sensitivity of perceiving long-range spatial relationships between features (e.g., the vertical distance between the eyes and mouth) is detrimentally affected by face rotation more than the sensitivity in perceiving short-range spatial relationships between features (e.g., the vertical distances between the eyes and eyebrows and the nose and mouth; the horizontal distance between the two eyes; Crookes & Hayward, 2012; Goffaux, 2008; Goffaux & Rossion, 2007; Goffaux, Rossion, Sorger, Schiltz, & Goebel, 2009; Sekunova & Barton, 2008). Thus, the misperception hypothesis would predict that the deleterious effect of drawing upside-down faces should be more strongly evident with respect to the reproduction of long-range than short-range spatial relationships between facial features.

This prediction was not tested by Cohen and Earls (2010) because, by using a single subjective rating to quantify the perceived spatial accuracy of the drawings, the accuracy of reproducing long-range versus short-range spatial relationships was not able to be distinguished. To test this prediction, the current study used objective measurements of drawing error to separately assess the effects of face inversion on the drawing of long-range and short-range spatial relationships between features. Participants drew one of four different faces twice: once while the model was upright and once while it was upside-down. For both the models and drawings, we measured (a) the vertical distance between the eyes and mouth as the long-range spatial relationship of interest and (b) the vertical distances between the eyes–eyebrows and the nose–mouth and the horizontal distance between the two eyes as the short-range spatial relationships of interest. These specific measures are consistent with how long-range and short-range spatial relationships between features were operationally defined in prior perceptual research studies (e.g., Sekunova & Barton, 2008).

Method

Participants

One hundred and twenty-six undergraduate psychology students participated in this experiment for course credit (83.52% female), *M* (*SD*) age = 20.76 (4.12) years old. All participants reported having no prior formal training in drawing.

Materials

Participants were randomly assigned to draw, two times each, one of four photographic models that each depicted a different person's face shown in the frontal view (two males and two females; see Figure 1). The models were presented on a 17-in. computer monitor (Dell Model: 1704FPVt). In one condition (*Upright condition*), the photograph was presented in the upright orientation. In the second condition (*Upside-down condition*), the photograph was presented as a 180° rotation of the upright photograph.

Participants were provided with an 8.5×11-in. sheet of white paper, a sharpened No. 2 pencil with an eraser, and a manual pencil sharpener to use to create the drawing.

Procedure

After providing informed consent, the participants received an explanation that they would be producing two drawings based on a photograph of a face. Participants were instructed that their goal in creating the drawings was to copy the photograph exactly as it appeared. They were further instructed that

Figure 1. The four photographs that served as drawing models in this experiment.

they should not add any details that were not present in the photograph and that they should not eliminate any important details that were present in the photograph. Furthermore, participants were instructed to draw the face as they saw it presented on the computer monitor. Specifically, when drawing the upside-down photograph, they were asked to draw an upside-down face as opposed to trying to draw an upright face based on a mental rotation of the upside-down photograph. Finally, they were told that they could use the eraser and pencil sharpener if they needed. Participants were given a 15-minute time limit to create each drawing.

A repeated measures experimental design was used, where participants drew the face one time each in both orientation conditions. The order in which the upright and upside-down drawings were produced was counterbalanced across participants.

For each of the model photographs and drawings, six measurements (A to F) were made (see Figure 2).

- "A" was measured as the height of the head (the vertical distance between the top of the head and the bottom of the chin).
- "B" was measured as the width of the head (the horizontal distance between the left and right top intersections of the ear and the face).
- "C" was measured as the vertical distance between the center of the eyeline and the bottom of the lower lip.
- "D" was measured as the vertical distance between the center of the eyebrow line and the center of the eyeline.
- "E" was measured as the vertical distance between the bottom of the nose and the bottom of the lower lip.
- "F" was measured as the horizontal distance between the inner corners of the two eyes.

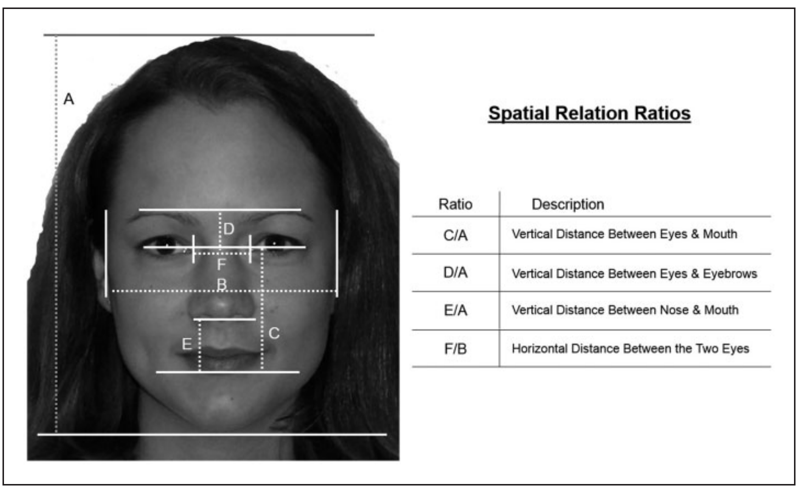

Figure 2. Illustration of the six measurements (A to F) that were made of each model photograph and drawing, and a description of the four spatial relation ratios used to measure one long-range spatial relationship between features (C/A) and three short-range spatial relationships between features (D/A, E/A, and F/B).

Based on these measurements, one long-range and three short-range *spatial relation ratios* were calculated to quantify the relative positioning of target facial features.

- Ratio "C/A" quantified the vertical distance between the eyes and the mouth relative to the height of the head. This ratio quantified the one long-range spatial relationship of interest to this study.
- Ratio "D/A" quantified the vertical distance between the eyes and the eyebrows relative to the height of the head. This ratio quantified one of the short-range spatial relationships of interest to this study.
- Ratio "E/A" quantified the vertical distance between the nose and mouth relative to the height of the head. This ratio quantified one of the short-range spatial relationships of interest to this study.
- Ratio "F/B" quantified the horizontal distance between the eyes relative to the width of the head. This ratio quantified one of the short-range spatial relationships of interest to this study.

See Table 1 for the C/A, D/A, E/A, and D/B values of each of the four model photographs and the mean and standard deviation values of their associated upright and upside-down drawings.

Absolute drawing errors for each of the four spatial relation ratios were calculated for each of the two ratios as follows:

Absolute Drawing Error = | Drawing Ratio Value – Model Ratio Value |

Results

Because we quantified drawing errors as absolute values, their distributions were positively skewed and thus violated the assumptions of normality that are associated with parametric inferential tests. Therefore, we used nonparametric tests for our analyses.

First, we aimed to determine if the magnitude of drawings errors differed between the four photographic models. We performed eight Kruskal–Wallis tests ($df = 3$) comparing the four models with each other with respect to the errors made in drawing the four measured spatial relationships in both the upright and upside-down drawings (the interocular distance and the distance between the eyes–mouth, eyes–eyebrows, and nose–mouth). All eight analyses indicated that the drawings of the four models did not significantly differ from each other with respect to the magnitude of drawing error (all p values were greater than the Bonferroni-corrected alpha level of .006). Because of this, we combined the drawings of all four models together in the following analyses.

Table 2 displays descriptive statistics pertaining to the absolute errors in reproducing the four spatial relationships in the upright and upside-down drawings. To determine if the magnitude of spatial drawing errors differed between

Table 1. Spatial Relation Ratio Values of the Four Models and the *M* (*SD*) Values of Their Associated Drawings.

		Model 1 ($n = 36$)	Model 2 ($n = 28$)	Model 3 ($n = 32$)	Model 4 ($n = 30$)
C/A	Model	0.3471	0.3558	0.3180	0.3421
Distance between eyes and mouth	Upright drawings	0.3995 (0.0311)	0.3904 (0.0547)	0.3829 (0.0446)	0.3935 (0.0424)
	Upside-down drawings	0.4132 (0.0538)	0.4122 (0.0556)	0.3859 (0.0601)	0.4070 (0.0603)
D/A	Model	0.1059	0.0833	0.1016	0.0822
Distance between eyes and eyebrows	Upright drawings	0.0976 (0.0191)	0.1037 (0.0130)	0.1113 (0.0171)	0.0861 (0.0154)
	Upside-down drawings	0.0977 (0.0255)	0.0973 (0.0128)	0.1180 (0.0231)	0.0905 (0.0211)
E/A	Model	0.1412	0.1474	0.1443	0.1370
Distance between nose and mouth	Upright drawings	0.1704 (0.0301)	0.1534 (0.0274)	0.1726 (0.0236)	0.1678 (0.0251)
	Upside-down drawings	0.1706 (0.0259)	0.1610 (0.0285)	0.1665 (0.0402)	0.1657 (0.0344)
F/B	Model	0.2522	0.2216	0.1795	0.2368
Distance between the two eyes	Upright drawings	0.2361 (0.0554)	0.2110 (0.0625)	0.2095 (0.0515)	0.2537 (0.0465)
	Upside-down drawings	0.2222 (0.0639)	0.2065 (0.0599)	0.2129 (0.0639)	0.2270 (0.0581)

Table 2. Absolute Drawing Errors: | Drawing Ratio Value – Model Ratio Value |.

		Mdn	25th Percentile	75th Percentile	Interquartile range
C/A	Upright drawings	0.0478	0.0257	0.0727	0.0470
Distance between eyes and mouth	Upside-down drawings	0.0634	0.0238	0.1008	0.0770
D/A	Upright drawings	0.0130	0.0046	0.0248	0.0202
Distance between eyes and eyebrows	Upside-down drawings	0.0179	0.0085	0.0270	0.0185
E/A	Upright drawings	0.0285	0.0113	0.0439	0.0326
Distance between nose and mouth	Upside-down drawings	0.0227	0.0122	0.0442	0.0320
F/B	Upright drawings	0.0449	0.0228	0.0647	0.0419
Distance between the two eyes	Upside-down drawings	0.0440	0.0227	0.0795	0.0568

the upright and upside-down drawings, four Wilcoxon tests were performed, one for each of the four spatial relationships we measured (adopting a Bonferroni-corrected alpha level of .013).

Long-Range Spatial Relationship

With respect to errors in reproducing the vertical distance between the eyes and mouth (C/A ratio), participants produced reliably larger errors when drawing the face from the upside-down model than when drawing it from the upright model, $Z = 3.782$, $p < .013$.

Short-Range Spatial Relationship

With respect to errors in reproducing the three short-range spatial relationships between features, participants did not reliably differ in the magnitude of errors they produced between their drawings of the upright and upside-down faces. This was evident with respect to (a) the vertical distance between the eyes and eyebrows (D/A ratio), $Z = 2.184$, $p > .013$; (b) the vertical distance between the nose and mouth (E/A ratio), $Z = 0.369$, $p > .013$; and (c) the horizontal distance between the two eyes, $Z = 0.768$, $p > .013$.

Control Analyses

Because the vertical distances between the eyes and mouth, eyes and eyebrows, and nose and mouth were measured as a proportion of the height of the head, it is important to establish that the average drawn height of the head was not confounded with the orientation conditions. In other words, it is important to establish that the average drawn height of the head did not significantly differ between the upright and upside-down drawings. As reflected by the "A" measurement, there was no significant difference in the reproduced head height between upright and upside-down drawings, $t(125) = 1.55$, $p > .05$. Further, because the horizontal distance between the eyes was measured as a proportion of the width of the head, it is also important to establish that the drawn width of the head was not confounded with the two orientation conditions. As reflected by the "B" measurement, there was no significant difference in how wide the head was reproduced between upright and upside-down drawings, $t(125) = 0.13$, $p > .05$.

Discussion

Here, we extend on the research of Cohen and Earls (2010) by demonstrating that drawing upside-down models selectively impairs the accuracy of drawing long-range, but not short-range, spatial relationships between facial features. This observation adds to the body of research that provides empirical support of the misperception hypothesis of drawing accuracy (Cohen & Bennett, 1997) that proposes that drawing errors are, to some degree, caused by inaccurate perceptual encoding of the model being reproduced. To date, the strongest empirical support of this hypothesis have come from studies that evaluated patterns of perceptual and drawing errors on a standard set of stimuli that are known to produce systematic patterns of error in perceptual judgment. Such studies have demonstrated that patterns of error in perceiving the relative length of lines (Mitchell, Ropar, Ackroyd, & Rajendran, 2005) and the size of angles (Ostrofsky, Kozbelt, & Cohen, 2015) are congruent and positively correlated with the patterns of error produced when drawing when perceptual judgments and drawings are based on the same set of stimuli. The current study adds to the empirical support of the misperception hypothesis because the pattern of spatial drawing errors induced by face inversion is congruent with the pattern of errors previously observed when individuals perceive the spatial relationships between features in upside-down faces (Crookes & Hayward, 2012; Goffaux, 2008; Goffaux & Rossion, 2007; Goffaux et al., 2009; Sekunova & Barton, 2008).

The results of this study are also consistent with past research that has failed to provide any empirical support for the idea promoted by Edwards (2012) that drawing models of common objects upside-down facilitates drawing performance. When considering our results in conjunction with those of Cohen and Earls (2010), the evidence to date indicates that drawing from upside-down models has, at best, no effect (with respect to the perceived accuracy of the individual facial features and the objectively measured accuracy of drawing short-range spatial relationships between features) and, at worst, an impairing effect on drawing accuracy (with respect to the objectively measured accuracy of drawing long-range spatial relationships between features).

However, it is worth noting that drawing from upside-down models may improve some aspects of accuracy not addressed in this study. For instance, Kozbelt, Seidel, ElBassiouny, Mark, and Owen (2010, Study 2) used a face-tracing task where participants were limited in the number of lines they could use to depict a face, which was oriented either upright or upside-down. Artist, but not nonartist, judges rated the upside-down tracings as more accurate than the upright ones. Because this was a tracing task, this benefit was not related to accurately depicting spatial relationships between features. Kozbelt et al. (2010) speculated that the source of increased accuracy in upside-down tracings involved accurately depicting the appearance of local features, suggesting that viewing a face upside-down results in paying more attention to the local details of a model face than when viewing it upright. This speculation is consistent with an observation that expert artists exhibit reduced holistic processing of faces (Zhou, Cheng, Zhang, & Wong, 2012). This is somewhat inconsistent with Cohen and Earls (2010), who reported no orientation difference with respect to accuracy ratings of individual facial features. However, Cohen and Earls's raters were nonartists; notably, accuracy ratings of nonartist raters in Kozbelt et al.'s (2010) study did not distinguish upright from upside-down depictions. Perhaps the individual features of upside-down drawings analyzed by Cohen and Earls would have been rated as more accurate if assessed by artists, as artists may be more sensitive to certain aspects of depiction. That said, there may also be other differences between limited-line tracing and freehand drawing, despite previously observed positive correlations between performance on the two tasks (Ostrofsky, Kozbelt, & Seidel, 2012).

Further, limitations of the current study and Cohen and Earls (2010) may also have prevented the discovery of facilitating effects of model inversion. For instance, these two studies investigated the effects of model inversion on drawing performance with a narrow focus on face stimuli. Thus, it is still open to question as to how model inversion affects drawing performance when nonface models are being reproduced. Another limitation of these two studies is that participants were allowed only a single 10- or 15-minute attempt to draw the upside-down-oriented model. It might be possible that the facilitating effects of model inversion emerge only after individuals are given more time to complete the drawing—for instance, Edwards (2012) provided an instruction for readers to work on an upside-down drawing for at least 40 minutes—or multiple opportunities to practice drawing from upside-down models. Thus, future research aimed at empirically evaluating the effectiveness of this popular art-instruction technique would benefit from extending the range of object categories that are assessed and by manipulating the level of experience participants have in drawing upside-down models. Nevertheless, under the conditions of the current study, the results reported here are inconsistent with the assertion that drawing from upside-down models improves drawing accuracy and thus raises doubt concerning the effectiveness of this long-promoted practice in the realm of art instruction.

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