Learning to draw: Does the inversion technique work?

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Several methods for teaching draftsmanship include exercises based on Edward’s “inversion” technique, the practice of copying from upside-down originals. We tested the technique by asking 40 artistically untrained participants to copy either upright or upside-down drawings of a face or a car. Our results indicate that participants were faster when copying the car in comparison to the face, but not when copying upside-down in comparison to upright images. In addition, they were more accurate in capturing the global proportions of the image in comparison to the local proportions of its parts. However, neither the face nor the car were copied more accurately in the upside-down relative to the right-side up condition. These results provide no evidence that Edward’s inversion technique promotes greater resemblance to the original stimulus image. Implications for the cognitive psychology of drawing and for the pedagogy of the visual arts are discussed.

Keywords: drawing, inverted drawing, learning, innocent eye

Highlights:

• Experimental investigation of the inversion technique promoted by Edwards (2012).
• Three different metrics compute objective evaluation of the accuracy of the draftsmanship.
• No evidence for an advantage of upside-down drawing.

Drawing is a fascinating form of visual art. Historically, humans drew pictures even before they started to write — and some did so better than others. How can we explain differences in drawing skills? Traditionally, two theories have tried to explain why and how some of us can draw artistically.

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According to the first theory, drawing skills depend on bottom-up processing, namely, on the ability to perceive the world in a special way. In ordinary vision, the retinal projection of outside objects is subjected to continuous changes as one changes the position of the viewpoint. For instance, moving closer to the object enlarges the retinal projection, whereas moving sideways produces slant. Despite these changes, we ordinarily perceive object size, shape, and position as unchanging and essentially veridical. In drawing, the situation is different. The artist is trying to reproduce the retinal projection that corresponds to an outside object, such that when seeing the reproduction a viewer will recognize the resemblance. To access the properties of the retinal projection, however, an artist must be able to “undo” the automatic mechanisms that process retinal information to yield percepts that more faithfully represent state of affairs in the external world. (These are often summarized under the rubric of “perceptual constancy”, underscoring how percepts maintain stable features in the face of continuous retinal modifications, such as those due to changes in viewpoint distance or position). Ruskin (1912) called the ability to access properties of retinal projections the “innocent eye”. He suggested that the innocent eye is the ideal that will never be attained perfectly, but needs to be continuously pursued to attain accuracy in drawing (Ruskin, 1843, cited in Rosenberg, 1963).

According to the second theory, drawing skills instead depend on the development and storing of internal representations. This top-down approach is related to Ernst Gombrich’s conception of schemata (1960, see also Kozbelt & Seeley, 2007), mental structures organizing knowledge relevant to drawing such as, for instance, knowledge about object structure, the proportions of the human body, or the rules of perspective. In this view key to drawing accuracy is having a repertoire of heuristics. These heuristics are applied to achieve accuracy in drawing by means of deliberate, strategic operations. Rather than learning a novel, “innocent” mode of perceiving, drawers need to develop conceptual structures to improve their drawing skills.

The two theories need not be mutually exclusive. There is currently consistent evidence that there are several strategic differences between the ways artists and novices draw. While earlier evidence stressed that these differences are related to perceptual abilities (Cohen & Bennett, 1997; Cohen & Jones, 2008; Kozbelt, 2001; Mitchell, Ropar, Ackroyd, & Rajendran, 2005), more recent studies have suggested that these may instead have to do with attentional and oculomotor strategies (Perdreau & Cavanagh, 2011). For instance, there is evidence that artists switch gaze between their drawing and the to-be-copied-from model more often and that gaze frequency correlates positively with accuracy (Cohen, 2005; see also Tchalenko, 2009). Recent findings are also beginning to reveal structural differences in brain structure between artists and novices. In particular, there may be correlations between drawing ability and grey/white matter volume in the left anterior cerebellar cortex and the right medial frontal lobe, regions that correspond to the supplementary motor area.
(SMA) and that have been implicated in integrating visual information with hand movements and with memory (Chamberlain et al., 2014). In addition, procedural memory may also play a role in shifting selective attention and promoting visual recognition (Kozbelt & Seeley, 2007). These findings generally corroborate the idea that the “artist’s advantage” is related to superior abilities in encoding object structure, presumably by integrating information across fixations, and in coordinating this knowledge with motor performance (Perdreau & Cavanagh, 2013; 2014). Thus the artist’s advantage is presumably related to both bottom-up and top-down processes (Ostrofsky, Kozbelt, & Seidel, 2012).

But what kind of training better promotes drawing ability? In what is now considered a classic in the pedagogy of the visual arts, Drawing on the Right Side of the Brain, art teacher Betty Edwards proposed that drawing could be learned by exercises that develop a specific perceptual and cognitive attitude (Edwards, 2012). Key to these exercises is the assumption that the right hemisphere is responsible for creativity and spatial processing, while the left hemisphere is responsible for language and semantic processing. Thus, Edward’s techniques strive to teach switching to “R-mode”, that is, engaging the right brain and de-emphasizing contributions from the left brain. First and foremost among these is the “inversion technique”. According to Edwards, even if you were always incapable of drawing, your skills will improve if you practice copying originals that have been rotated by 180 degrees. Reportedly, presenting the original upside helps viewers to better detect structural information and spatial relations between the picture elements, such as edges and shapes, and reduces the influence of semantics. This therefore promotes a greater ability in reproducing this information on the sketchpad.

The inversion technique is widely adopted in art schools. For instance, a web search for exercises to learn drawing quickly reveals several online programs including exercises based on the inversion technique. But is there an evidence that the technique actually works? Current evidence on this issue is mixed. In the original study reported in her doctoral dissertation (Edwards, 1976), Edward projected slides of two complex images and compared performance in drawings copies when these were upright or inverted and when the instructions stressed analyzing naming of single parts or structural information such as of parts-whole relations, angles, shapes, and spaces. In the inversion manipulation, she used a drawing by Picasso (the Portrait of Stravinsky), whereas in the instruction manipulation she used a black-and-white photograph of James Joyce. Participants had twenty-five minutes to complete the copy on paper using a pencil. The drawings were then scored by five art teachers on a five-point scale for degree of resemblance to the original image. To guide them in the scoring, Edwards provided sample drawings with suggested scoring. The results showed that the judges awarded higher scores to copies from the inverted original and to copies produced under the structural instructions, in comparison to the upright originals and the analytical instructions. Edwards therefore interpreted her results as supporting the hypothesis that inverting the original promotes better drawings by enhancing the processing of visual structures and spatial relations.
Edwards’ early observations are interesting. However, interpreting them as evidence for the validity of the inversion technique is not straightforward. The degree of resemblance between the copies produced by the participants and the original was not evaluated based on a quantitative metric, but on subjective evaluations by five judges. The instructions given to the judges, who stressed artistic quality rather than resemblance, may have favored scores that were more based on idiosyncratic notions of what is a “good” drawing rather than copying accuracy. The reference drawings provided to anchor the scores might also have biased the results in unknown ways. In addition we note that the comparison of a non-realistic drawing such as Picasso’s with a photograph is also difficult. For all these reasons, the interpretation of Edwards’ results requires caution.

Other studies also do not provide definitive evidence. Kozbelt, Seidel, ElBassiouny, Mark, and Owen (2010) tested the inversion technique by comparing artists and non-artists in a drawing task. Their drawings were evaluated on several dimensions by an artist and non-artist panels. Kozbelt and colleagues reported that the non-artist panel did not find the inverted drawing conditions to be better than the right-side up condition. The artist panel, however, did find the inverted drawing condition to yield better drawings. This result however was not obtained with a copying task, but with a rather idiosyncratic drawing task. Participants were given a photograph inserted in a plastic folder and were asked to reproduce it by tracing over it. The task therefore emphasized the selection of elements to be traced rather than the ability to capture relative positions and proportions. For this reason, the extent to which this finding is relevant to Edward’s claim remains unclear. Cohen & Earls (2010) tested whether inverting the model increases copying accuracy for spatial (global relative positions and proportions) and featural (shape of individual elements) processing. They recruited 72 novices and 49 experts and each was assigned to one of the two conditions. The drawings were then evaluated by four college art teachers, who scored them on three dimensions: featural detail, spatial detail, and overall accuracy. In contrast with Edwards’ early report, the results documented worse spatial detail accuracy by both novices and experts in the inversion condition. Finally, Cohen (2005) also reported that judges did not find copies from upside-down models to be more accurate than those from right-side up models (although this study was aimed at assessing the relationship between accuracy and gaze frequency).

Thus, whether the inversion technique actually works remains a matter of debate. In addition, we emphasize that all the current evidence is based on judgements of artistic merit by panelists. To the best of our knowledge, no study has sought to measure, with a quantitative approach, the degree of resemblance between the copy and the original. Such quantitative measures provide important complementary information about drawing performance (Carson, 2012; Ostrofsky, Cohen, & Kozbelt, 2014). In the present study, we examined whether individuals with no training in drawing do actually draw better copies from inverted originals. We used two simple black-and-white drawings, a face
and a car, which we selected as comparably complex but representative of
patterns that might be differently affected by inversion. It is well known that the
recognition of faces is disproportionately affected by inversion in comparison
to the recognition of objects (Yin, 1969). To quantify participants’ performance,
we measured the times needed to complete the copies (as an indicator of task
difficulty) and computed several quantitative indexes of resemblance between
the original and the copy.

Method

Participants

Forty members (15 males, 4 left-handed, mean age 22 years) of the Parma student
community volunteered. None had received formal training in drawing, and all were unaware
of the purpose of the study.

Ethics

The treatment of the sampled participants fully complied with APA ethical standards as
well as with the ethical standards of the Italian Board of Psychologists (see http://www.psy.it/
codice_deontologico.html).

Stimuli, Apparatus, and Procedure

The stimulus images (Figure 1) were presented on the upper half of an A4 white
sheet. The lower half of the sheet was left blank for the participant’s copy. Four different
sheets were used depending on the figure to be copied (face or car) and on its orientation
(upright or upside-down). Participants were given a B-grade pencil and an eraser. The time
to completion of the drawing was recorded using a digital chronometer. Various measures
of copying accuracy were measured by comparing distances between selected points of the
original and copied images, as measured by a suitable set of rulers. The experiment began by
recording the participant’s age as well as his or her preferred hand for writing as an indicator
of handedness (for a justification of this method of determining handedness, see Rigal, 1992).
Next, they were presented with one A4 sheet (turned to show the back of the page which had
no drawing) and asked to read the following instructions: “You will be presented with two
sheets containing two images, one at a time. Your task is to reproduce the figures as best as
you can. Use the space in the lower part of the sheet to reproduce the figure. Take as much
time as you need and feel free to use the eraser. However, please keep the sheet always in
the orientation that was originally presented and avoid rotating the sheet. After a go signal,
turn the sheet and begin.” If participants require additional explanations, the experimenter
provided further clarification. Once the task was clear, the experimenter provided the first go
signal, started the chronometer, and the participant started to copy the first stimulus image.
At the end of the experiment participants who asked for an explanation, were debriefed. The
dependent variables were the time to completion of the copy and two measures of accuracy
in reproducing the original proportions (see below). The independent variables were the
orientation of the stimulus original (upright or upside-down) and the type of stimulus (face or
car). To control the effect of order, a Latin square was used to randomly assign 10 participants
to each of four conditions: upright car, upside-down face; upright face, upside-down car;
upside-down car, upright face; upside-down face, upright car. In each condition, participants
copied each drawing in the specified order and orientations.
Analysis

We inspected histograms of the distributions of the times to completion of the drawings (fig. 2) separately for the four conditions. Given the differences in the shape, dispersion, and symmetry of the four distributions, we measured the central tendency of these distributions using their medians and tested differences using Mann-Whitney’s nonparametric two-sample test.

To assess participant’s accuracy in copying the stimulus images, we computed three different measures. The first and second were designed to capture two specific features of the spatial structure of the drawing: the ratio of the horizontal and the vertical total extent of the drawn pattern, and the ratio between the horizontal and vertical extent of local features within the pattern. We chose to assess both local and global accuracy, because it is unclear whether the inversion technique affects the overall picture or only local elements of the drawings. In the study of Cohen & Earls (2010) the global relative positions of parts (which they called spatial detail) was the only measured showing a difference between inverted and right-side up stimuli. We call the first the global aspect ratio (global AR) and the second the local aspect ratio (local AR), see Figure 2.

Global AR’s were: i) for the face, the horizontal distance between each ear-cheek junction and the vertical distance between the highest point on the hair contour and the
lowest point on the chin contour (again, see Figure 2); ii) for the car, the horizontal distance between the left- and rightmost points, on the car front and back bumpers, respectively, and the vertical distance between the highest and lowest points of the car frame. Local AR’s were: i) for the face, the horizontal distance between the pupil centers and the vertical distance between the eye level and the lowest point of the nose contour; ii) for the car, Local car AR1 – the horizontal distance between the left- and rightmost points and the vertical distance between the highest and lowest points of the front door. Local car AR2 – horizontal distance between the left- and rightmost points and vertical distance between the highest and lowest points, for the back door.

To obtain summary measures of drawing accuracy based on the global and local AR’s, for each participant we computed percent measures of deviation from the original image as follows:

\[
\% \text{ deviation} = \frac{(AR_c - AR_o)}{AR_o} \times 100
\]

where ARc is the relevant aspect ratio in the copied image, and ARo is the corresponding aspect ratio in the original stimulus. Note that, because AR’s were computed by dividing horizontal by vertical distances, values greater than one indicate figures that are more elongated horizontally than vertically, and values smaller than one indicate the opposite. When computing the difference between the copy and the original AR, this entails that a negative sign signifies a copy more elongated vertically than the original, and a positive sign a copy more elongated horizontally.

The third measure was instead designed to capture overall resemblance with no specific focus on local or global features. This measure was adopted from the metric proposed by Perdreau & Cavanagh (2014). It is based on the notion of selecting a common origin point for both the original and the copy and on measuring relative distances between this point and all other points that can be unambiguously identified in both the copy and the original. Based on Perdreau and Cavanagh’s metric, we computed an overall measure of deviation from the original image as follows. First, we chose 16 junctions that could be readily located on both the original drawings and on the participants’ copies. Next, we centered both the original picture and the copies on the leftmost selected junction (this was therefore the common origin point; for instance, imagine an equilateral triangle — the leftmost corner will be selected). Finally, we normalized the coordinates to the maximum horizontal and vertical coordinates. This yielded a root-mean-square measure of deviation of the copy from the original image, computed as:

\[
\% \text{ RMSE} = \sqrt{\frac{\sum (C_d - C_o)^2}{n} \times \frac{100n}{\sum C_o}}
\]

where Cd and Co are the relative coordinates of the participant’s copy and of the original, and \( n \) is the number of selected points. This measure is the mean of the percentage root-mean-square error calculated for each axis, x and y.
Results

The distributions of the times to completion of the drawings are presented in Figure 3. Times tended to be lower in the upright car condition (median = 278 s) in comparison to the other three conditions (medians = 362 s, 351 s, and 371 s, for the upright face and upside-down face and car, respectively). However, the difference between faces and cars proved statistically reliable, Mann-Whitney $U = 3282$, $p < .005$, whereas the difference between upright and upside-down did not, Mann-Whitney $U = 4208$, $p > .75$.

![Figure 3](image-url)

*Figure 3.* Times to completion of the copying task in the four conditions of our study.

Distributions of percent deviations from the original images are presented in Figure 4, separately for each measure and orientation. Overall, participants tended to produce copies of the face that were more elongated...
horizontally than the original (positive % measures), and copies of the car that were more elongated vertically (negative). Additionally, they tended to be more accurate with the car (average deviation –3.3%) than with the face (7.7%) and, to a lesser extent, in the local (0.5%) in comparison to the global measures (2.0%). However, results did not show sizable differences as a function of the orientation of the stimulus image, except for the global measure with the car stimulus, where the average percent distortion was 2.2% in the upright orientation but 10%, a fivefold increase, in the upside-down orientation. To subject the above-described pattern to inferential analysis, we entered the % deviation data into a 5 (type of measure) x 2 (orientation) ANOVA. This revealed a significant effect of type of measure, $F(4, 190) = 7.96, p < .0001$, but not of orientation $F(1, 190) < 1$ or of the interaction $F(4, 190) < 1$. Consistent with our qualitative assessment of the results, Scheffé post-hoc tests indicated that all car – face paired comparisons were statistically significant, $p < .05$ or lower, except for the comparison between the face global AR and the car local AR2, whereas only two (out of five possible) local vs global comparisons were significant, $p < .01$ or lower. Most importantly, no pairwise comparison between the upright and upside-down orientations within any of the five measure proved significant, $p > .11$ or larger. Accuracies based on Perdreau and Cavanagh’s %RMSE metric were analyzed using a 2 (Group: Car vs Face) x 2 (Condition: Original vs Upside-down) ANOVA. A significant effect of group, $F(1, 79) = 45.4, p < .0001$ was observed, indicating that participants produced smaller errors when they copied the car than the face. However, these data also did not show an effect of condition, $F(1, 79) = 0.05, p > .05$, or of the two-way interaction, $F(1, 79) = 0.053, p > .05$, indicating that there were no differences between the original and upside-down orientations of the models.
Figure 4. Global and local % Aspect Ratios deviation (AR) and Root Mean Square Deviation (RMS) of the car and the face stimuli reflecting the participants’ accuracy. A summary of the global and local aspect ratios are depicted in the third row of the first column. Note that local aspect ratios of the car refer to the anterior and posterior doors labelled as 1 and 2 in the figure.
Discussion and Conclusion

In a nutshell, our results indicate that participants were able to copy the car more quickly and accurately than the face, and that there were differences of detail in the ability to reproduce the proportions of the original image. These differences are to be expected given the simpler geometry of the car image, and are not particularly surprising. Importantly, however, we failed to observe any systematic difference between copies from the upright and the upside-down orientations of the original image. If anything, we observed a (non-significant) tendency towards greater accuracy in the upright condition with the face stimulus. Thus our results are not consistent with expectations based on the inversion technique promoted by Edwards (2012).

It may be argued that our results are inconclusive in that we obtained non-significant effects. However, our study did reveal several significant differences, although not between the orientations of the original stimulus image. For this reason, it seems unlikely that we failed to observe an advantage of upside-down drawing due to insufficient statistical power. In addition, our sample size, 20 participants in each orientation condition, was comparable to that of the original study reported by Edwards (1976) which had 21 participants in each orientation. Moreover each of our participants produced two drawings, effectively doubling the number of observations. Finally, we stress that if any hint of an overall difference is to be detected in our data, it was in fact in the direction of an upright advantage, not the other way around. We also stress that similar results were obtained with two different accuracy metrics, one emphasizing key features encompassing local and global properties, and a second adopting the more neutral approach of Perdreau and Cavanagh (2014). Thus, the results are unlikely to depend on the choice of a given method for assessing accuracy.

An alternative criticism to our study may be that our data are noisy due to insufficient control of skill level. Although we purposely chose to test only individuals with no formal training in the visual arts, some of them might still enjoy drawing as a hobby or pastime, which would effectively endow them with a degree of informal training. For this reason, one could argue that these participants cannot be considered completely unskilled. To further test this possibility, after completing the drawings 25 of the 40 participants were asked to fill out a four-item questionnaire. The questionnaire items were the following: “I practice drawing often”; “I believe I can draw well”; “I found the upright image easier to copy than the upside-down image”; “I found the face easier to copy than the car”. Participants reported their degree of agreement with each item on a 1 (completely disagree) to 7 (completely agree) scale. The median agreement scores to the first item was 2, with all participants choosing scores of 3 or less except for four participants that choose 7, 6, 5, and 4. The median agreement scores to the second item was also 2, with all participants choosing scores of 4 or less except for three participants that choose 5 (corresponding to three of the four reporting that they drew often). Thus, there was little evidence that, overall, participants were informally trained or otherwise practiced drawing.
Interestingly, the median agreement scores to the third and fourth items were 4 and 5, suggesting that participants did not perceive task difficulty to vary with image orientation, but perceived the face to be easier to draw than the car (the opposite of what we observed in our measures).

Although we do not believe that our results suffer from insufficient statistical power, our study has other limitations. First of all, our conclusions are necessarily limited to the two kinds of figures that were tested. It may be that with different categories of figures the upside-down drawing technique proves more useful. We also stress that the drawings tested by Edwards were considerably different from ours. It may also be that unskilled participants require more training, perhaps over several days, before the effect of upside-down drawing begins to show. We stress however that in the original study reported by Edwards (1976) an advantage of upside-down drawing was reported after a single drawing session as in our study.

But perhaps the most important consideration in comparing our study to Edwards’ concerns the assessments of the quality of the participants’ drawings. In our study, we sought quantitative indices of performance, based on drawing times and on comparing the original and of the copy in three different ways. In Edwards’ study, instead, the quality of the participants’ drawings was evaluated qualitatively by a panel of experts. Although quantitatively they did not turn out to be more accurate in the upside-down condition, it is quite possible that the copies might have nonetheless been judged as artistically “better” by a panel of judges. We stress that the artistic quality of a drawings is however a different problem than its degree of consistency of a copy with the original. If there is a dissociation between the two, this would be interesting to learn. These limitations notwithstanding, we conclude that at least in the current conditions there is little evidence in support of Edwards’ inversion technique. According to Edwards, these exercises are specifically designed to cause a (hypoththesized) mental shift from L-mode to R-mode to promote greater focus on the visuospatial features of the image. Our current results do not support this hypothesis, although further research will be needed to explain the discrepancy with Edward’s experiment.

References


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