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Why Can't Most People Draw What They See?

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The study presented a theoretical and empirical approach to the adult drawing process. Four possible sources of drawing inaccuracies were described: misperception of the object, inability to make good representational decisions, deficient motor skills, and misperception of the drawing. In four studies the degree to which the latter three sources contributed to drawing inaccuracies was assessed. The results suggest that (a) motor coordination is a very minimal source of drawing inaccuracies, (b) the artist's decision-making process is a relatively minor source of drawing inaccuracies, and (c) the artist's misperception of his or her work is not a source of drawing inaccuracies. These results suggest that the artist's misperception of the object is the major source of drawing errors.

Although children's drawing abilities have been studied extensively (e.g., Broderick & Laszlo, 1989; Freeman, 1980, 1987; Lee, 1989; Reith, 1988; Wolf & Perry, 1988), those of adults have been relatively ignored in the scientific literature. There have been extensive accounts of the adult drawing process in the art history literature (e.g., Arnheim, 1986; Gombrich, 1984; Richter, 1970; Rosenberg, 1963; Sze, 1956). These accounts are important because they provide working theories, but they lack empirical support. This article presents a theoretical and empirical approach to the adult drawing process; our discussion is strictly limited to the visual accuracy of drawings of a photograph.[1]

Our use of the term *visual accuracy* suggests that an objective description of accuracy can be made. This description, however, is both culturally determined and difficult to describe (see Gombrich, 1984). We operationally defined a visually accurate representation as one that can be recognized as a particular object at a particular time and in a particular space, rendered with little addition of visual detail that cannot be seen in the object represented or with little deletion of visual detail. According to this definition, a photograph is an excellent example of a visually accurate, two-dimensional representation because it adds and deletes very few visual details. Picasso's *Guernica*, however, although a great work of art, would probably rank low as an example of a visually accurate representation. Because this definition relies on a viewer's judgment, however, the visual accuracy of any specific work of art is ultimately a subjective decision. For the remainder of this article, all subjective and cultural influences are implied if not explicitly stated.

The Drawing Process

The act of drawing is a complex and elusive process. In an attempt to analyze the drawing process, we allow the details of the process to blur in order to gain a more comprehensive understanding of the whole. With this in mind, we dissected the drawing process into four broad abilities.

To realistically render a vase, for example, an artist must (a) perceive the vase as it exists in space, (b) decide which areas of the vase to represent and how to represent those areas, (c) have the motor coordination to translate those decisions into physical marks on the paper, and (d) objectively assess the accuracy of those marks and correct any inaccuracies (which involves all of the previous abilities). An artist's inability to realistically depict an object may result from a deficiency in one or more of these four abilities. The first potential deficiency (the misperception of the object) is enormously complex, and most perceptual psychologists agree that at present there exists no adequate description of this ability. Therefore we discuss this ability briefly but do not explore it in depth. The other three abilities, which are more tractable, are the focus of this article.

Misperception of the Object

As John Ruskin remarked, "The first great mistake that people make in the matter, is the supposition that they must

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[1] Often in great works of art the representation of an object does not bear a striking resemblance to the object itself (e.g., works by Chagall, Kandinsky, Matisse, Picasso, etc.). Because our goal was to assess the artist's technical abilities, we addressed only the realistic (vs. the impressionistic, expressionistic, or abstract) qualities of the drawings. We do not address the creative and stylistic decisions that made the works of the aforementioned artists so pleasing.

see a thing if it be before their eyes" (Rosenberg, 1963, p. 24). Ruskin warned the potential painter against the assumption that to see an object is to perceive it correctly. This warning has been documented as early as A.D. 415, when Wang Wei informed aspiring artists that "the form of the object must first fuse with the spirit, after which the mind transforms it in many ways" (Sze, 1956, p. 39). The artist's misperception of the object is the most extensively researched ability of the drawing process (Blakemore, 1973; Blakemore, Carpenter, & Georgeson, 1970; Deregowski, 1973; Freeman, 1980, 1987; Gregory, 1990; Lee, 1989; Reith, 1988). There are at least two distinctly different causes of the artist's misperception of an object: illusions and delusions.

Illusions

Illusions are defined as misperceptions that cannot be corrected through an act of will. When the physical cause of an illusion is known, it is apparent why the misperception cannot be corrected. For example, the brightness contrast illusion is the result of the lateral inhibition of photoreceptors in the retina. Not all illusions, however, can be unequivocally attributed to a physical cause. Take, for example, the Zollner illusion shown in Figure 1 (similar well-known illusions include the Ponzo illusion and the Müller–Lyer illusion). The angled lines are perceived as being askew in relation to each other when in fact they are parallel. Blakemore (1973) and colleagues (Blakemore et al., 1970) described a physical cause for this illusion; Gregory (1990) presented evidence against a physical cause. Regardless of the cause of this illusion, because this effect is universally perceived by various cultures (although to differing degrees; Deregowski, 1973) and there is no evidence that a force of will can overcome the effect, it is classified as an illusion. Both poor and accomplished artists are affected by illusions. Generally, an artist successfully copies an illusion by knowledge of its causes, not through a perceptual process.

Delusions

Delusions are defined as false beliefs that are held in spite of invalidating evidence (similar to Kanizsa's, 1979, "stimulus error"). Delusions can often be corrected through an act of will. Drawing inaccuracies resulting from delusions occur when the artist relies on information that he or she possesses about the appearance of the object or of similar objects rather than on the actual physical appearance of the object.[2] An example of an inaccuracy resulting from a delusion is an artist's painting river water blue when the water is actually a greenish brown. The artist relied on the "truth" that water is blue and ignored or failed to perceive the true color of the water.

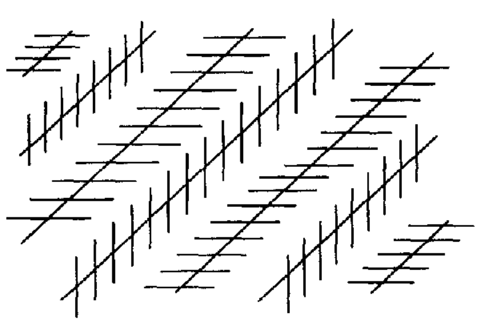

Figure 1. The Zollner illusion. Although the angled lines are parallel, they are seen as being askew in relation to each other.

Gombrich (1984) theorized that delusions are an integral part of the drawing process. He proposed that artists work from a memorized ideal of the object to be represented, termed a *schema.* To depict an object, an artist renders this schema and then matches that rendering to the original object. If inaccuracies are recognized, the artist corrects the rendering and may also adjust the schema. The artist's schema is by definition a source of delusion.

Drawing inaccuracies resulting from delusions have been extensively researched in children (Freeman, 1980, 1987; Lee, 1989; Reith, 1988). When copying an outline drawing of a table, for example, children make systematic errors that correspond to their knowledge of what a table looks like. However, when children copy outline drawings of parts of the table in isolation, they make very few copying errors (Lee, 1989). These results indicate that the children's knowledge of the form of a table is interfering with the accuracy of their drawings.

In adults, the most widely studied drawing inaccuracies resulting from delusions are those of distorted perspective (for a discussion, see Kubovy, 1986). Before artists learn the rules of perspective (both historically, before the rules were discovered, and currently, before young artists become acquainted with the rules), they often rely on their incomplete knowledge of foreshortening rather than on information gained through looking at the object. This incomplete knowledge can grossly distort reality. As a result, the paintings produced are frequently awkward.

Historically it was believed that drawing inaccuracies resulting from delusions could be overcome by practice and concentration. Leonardo da Vinci beseeched painters to find "relaxation in games . . . [that] practice such things as are used in your profession, by giving your eye good practice in judging accurately of the breadth and length of objects . . . which is of the first importance in painting" (Richter, 1970, p. 507). As Ruskin stated, "To do this no particular powers of mind are required, no sympathy with particular feelings, nothing which every man of ordinary intellect does not in some degree possess, powers, namely, of observation and intelligence, which by cultivation may be brought to a high degree of perfection and acuteness" (Rosenberg, 1963, pp. 23–24). However, Gombrich (1984) warned that the artist

[2] Throughout this article we use the term *drawing inaccuracy.* This term indicates the artist's failure to realistically represent an object. It is the antithesis of drawing a visually accurate representation. Because the definition of visual accuracy is both culturally determined and subjective, so too is the determination of drawing inaccuracies.

can overcome delusions only to a certain degree and that "the innocent eye is a myth" (p. 298). Although there is no experimental evidence that drawing inaccuracies resulting from delusions can be overcome, art students readily acknowledge these errors and correct them.

We cannot capture the complexity of this stage of the drawing process in this discussion of illusions and delusions. There are undoubtedly other sources of misperceptions. We also do not suggest that perception is the result of prior experience (although Rock, 1983, has made a convincing argument in favor of that claim). Illusions and delusions are simply likely sources of misperception that contribute to drawing inaccuracies.

Incorrect Representational Decisions

The second possible source of drawing inaccuracies is the artist's inability to make correct decisions about what visual information to represent and how to represent it. This ability is one of the major obstacles in computer vision (Ballard, 1984, 1986; Poggio, Gamble, & Little, 1988). The visual information included in a painting is limited by the artist's materials. The artist must make decisions about what information to omit and how to transform the included information into a format that can be adequately handled by the materials. For example, a photograph of a face contains both color and shading, but if an artist is to copy that photograph in ink, the artist must eliminate all color and most shading. Drawing inaccuracies may result from poor decisions.[3]

Gombrich (1984) presented an account supporting the theory that poor representational decisions significantly contribute to drawing inaccuracies. He argued that artists have long used "tricks" for representing the natural world. Artists have learned formulas for drawing objects, modified these formulas, and taught them to subsequent artists; these formulas are incorporated in the artist's schema. Increased realism resulted when some artists looked at nature, saw inconsistencies between nature and their pictures, and rectified the inconsistencies with the invention of new tricks. An artist cannot render an accurate drawing without knowledge of these so-called tricks. As Gombrich noted, "For so much certainly emerges from a study in art: you cannot create a faithful image out of nothing. You must have learned a trick if only from other pictures you have seen" (p. 83).

A more mundane understanding that is necessary to accurately render an object is knowledge of how to manipulate the rendering material. Different rendering materials, such as pencils, ink, brushes, oil paint, watercolors, and so forth, have different mark-making characteristics. Each characteristic requires specific motor movements to create a mark that successfully imitates the object. The characteristics of each rendering material must be known if an object is to be successfully rendered.

Motor Coordination

Once the artist has perceived the object as it exists and has made meaningful decisions concerning what and how to represent the object, the artist must be able to translate those decisions into physical marks on the paper. The artist must have the appropriate motor skills to adequately accomplish this task. This ability is a physical process, not a perceptual or cognitive process. If the artist's mark approximates the desired mark, the artist has the motor coordination necessary to create an accurate representation.

If drawing inaccuracies were merely a result of deficient motor skills, artistic skill would be a quality reserved for only the most dexterous. This seems not to be the case: Physically challenged artists often create very realistic renderings. It is assumed that adults from industrialized cultures have these general skills, whereas children do not (Broderick & Laszlo, 1989; Freeman, 1987).

Misperception of One's Drawing

A source of drawing inaccuracies that has not been much discussed is the artist's perception of his or her own drawing: "For you know how much a man is deceived in his own works" (Leonardo da Vinci, as quoted in Linscott, 1957, p. 67). Just as the artist must perceive the object as it exists, the artist must also perceive the drawing as it exists. This critical step allows for the correct evaluation of the artist's mark, which, if needed, allows for an accurate correction to be made. Drawing inaccuracies may remain uncorrected because the artist perceives the mark to be more accurate than it actually is.

Gombrich (1984) understood how important the artist's correcting a mistake is to the drawing process. He stated that "making comes before matching" (p. 116). The artist must make a mark, presumably based on a schema of the object, and then match that mark to reality. An artist's distorted perception of a mark would interfere with this process.

People may be extremely susceptible to this source of drawing inaccuracies. When an artist makes a mark, he or she generally assigns meaning to that mark. The meaning assigned to the mark may interfere with the artist's ability to objectively assess the accuracy of that mark. The result is an accuracy bias because the artist perceives the mark to be more accurate than it actually is.

The artist's inability to correctly assess the mark may be more debilitating than the artist's inability to correctly perceive the object. The artist who objectively perceives the mark can nullify the potential drawing inaccuracies resulting from the artist's misperception of the object (i.e., the artist can accurately copy an illusion). When the artist's misperception of an object is the result of an illusion, the artist's rendering should theoretically create the same illusory effect. Therefore, artists who correctly assess their own marks can copy the illusion despite their inability to correctly perceive the stimulus. Take the example of brightness contrast discussed earlier. The artist cannot see the two center regions as having equal intensities. However, when the artist deliberately paints the center of the dark region

[3] The appropriateness of all representational decisions is dependent on both culture and convention.

with a brighter color than he or she paints the center of the light region, lateral inhibition makes the center of the dark region in the painting appear brighter than does the center of the dark region in the standard. The artist who objectively perceives the painting should see the inconsistency between the painting and the standard. The correction would be a simple process of darkening the center of the dark region until it appears to be the same brightness as the standard. Similar explanations hold for other misperceptions, such as incorrectly perceived angles, lengths of lines, hue, saturation, and so on.

Although the artist's inability to assess his or her own mark is potentially a bountiful source of drawing inaccuracies, no empirical studies have addressed this source of drawing inaccuracies.

Summary

If drawing is the simple act of copying what one sees, then most people should be able to accurately draw what they see. This, however, is not the case. Most people find drawing to be an intimidating and difficult task. Although children's drawing abilities have been studied extensively, adults' drawing abilities have been somewhat ignored in the scientific literature. We have outlined four possible sources of drawing inaccuracies: (a) misperception of the object, (b) inability to make good representational decisions, (c) deficient motor skills, and (d) misperception of the drawing.

We present four studies that assessed the relative effect on the drawing process of the latter three sources of drawing inaccuracies. We successively removed one or more of these sources from the drawing process and compared the product of that isolation to the product of the complete process. By successively removing these sources of drawing inaccuracies, we assumed that any error associated with that source would also be eliminated. Thus, any remaining error would be the result of the sources not removed. In Experiment 1 we isolated the effects of representational decisions and motor coordination; in Experiment 2 we isolated the effect of motor coordination; in Experiment 3 we provided converging evidence for the conclusions of Experiments 1 and 2; and in Experiment 4 we isolated the effect of the artist's misperceiving his or her drawing.

In all of the experiments, we required the research participants to make a rendering of a color photograph, and the accuracy of those renderings was judged. We used color photographs as stimuli because they are complex enough to present the artist with difficult representational decisions (a quality that is not inherent in simpler line drawings), and they provide an unchanging view of a given stimulus (a quality that is not inherent in three-dimensional objects). We used accuracy ratings as a dependent variable to discover the relative contribution of each drawing ability to drawing inaccuracies. By comparing accuracy ratings of renderings produced using all four drawing abilities to the accuracy ratings of renderings produced using only two or three drawing abilities, we could assess the relative contribution of the removed ability to the drawing inaccuracies. It should be noted that ratings provide a global view of rendering accuracy without specifying the specific inaccuracies. Although an analysis of specific drawing inaccuracies may be useful, it is beyond the scope of this article.

Experiment 1

We conducted Experiment 1 to test whether the majority of drawing inaccuracies result from the artist's inability to make good representational decisions, from the artist's deficient motor skills, or from both sources of drawing inaccuracies. We asked participants either to trace a photograph, trace a photograph from a distance, or simply draw a photograph (with the photograph placed perpendicular to the paper). We used a 6 × 8.5 in. (15.24 × 21.59 cm) color photograph as the standard in order to force participants to make all necessary representational decisions.

In this experiment, the tracing condition was of critical importance. To trace a photograph successfully, an individual must make both good representational decisions and have adequate motor coordination. Tracing requires the same eye–hand motor coordination as drawing. The participant must be able to visually guide his or her hand to make the desired mark; the person who does not possess the required motor coordination will fail at this task. Furthermore, because the participant was to trace a color photograph, he or she had to make decisions about where and how to make the mark. Bad decisions resulted in a poor tracing.

To trace a photograph successfully, an individual does not need to correctly perceive either the object or the drawing.[4] The perception of the object and drawing is reduced to the local point-to-point assessment of the feature being traced and the mark of the pen. The correction process is reduced to a trivial matter of orienting the pen toward the desired feature to be traced. The participant, for example, does not need to perceive that the lines are parallel in the Zollner illusion or in his or her own drawing to successfully trace that stimulus.

By assessing both the participant's tracing and drawing abilities, we gain insight into the causes of drawing inaccuracies. If the participant's tracings and drawings are of equal caliber, we may conclude that the drawing inaccuracies resulted from either a lack of motor coordination or poor representational decisions. The additional steps present in the drawing condition, namely, the participant's correctly perceiving his or her own mark and the object, do not create added inaccuracies. If the participant's tracings are better than his or her drawings, then we can conclude that the grossest drawing inaccuracies are not the result of motor coordination or poor decisions because the participant's successful tracing depended on both good representational decisions and adequate motor coordination.

[4] Of course an individual cannot completely remove these sources of drawing inaccuracies because he or she must visually process both the photograph and the drawing. However, the likely sources of drawing inaccuracies associated with the misperception of the object and an individual's drawing (i.e., illusion, delusion, and an accuracy bias) become inconsequential when tracing.

Method

Participants

Twelve college students from the general psychology participant pool volunteered to participate as artists.[5] No artist had formal training in the visual arts. Sixty college students volunteered to participate as critics (30 rated the renderings and 30 ranked the renderings). We recruited the critics individually at the university library. We did not assess the critics' formal training in the visual arts; however, we assumed that if a critic had any formal training, it was minimal.

Materials

We used four 6 × 8.5 in. (15.24 × 21.59 cm) color photographs as stimuli in the rendering task. One photograph depicted a large campus generator, three quarters of which was visible. We chose this photograph for its well-defined rectilinear features (see Figure 2). We chose another photograph, which depicted the face of an African American woman, for its soft features (see Figure 3). Another photograph depicted the corner of a building's facade. The fourth photograph depicted a close-up view of rocks in a riverbank. We used all four photographs in the rendering task, but we used only the photos of the face and the generator in the critics' task because we did not want to overwhelm the critics.

In the rendering task, artists used a black wax pencil on clear transparencies. We had the artists use a wax pencil to ensure that they had adequate experience with the marking instrument because a wax pencil has the same characteristics as a graphite pencil. The wax pencil also has the advantage of making clear marks on a transparency. We wanted the artists to use the transparencies to ensure that they had an unobstructed view of the photograph in the two tracing conditions. The artists used a table consisting of a clear plastic shelf, the face of which was 18 × 12 in. (45.72 × 30.48 cm) and which stood 12 in. (30.54 cm) high. This shelf afforded an unobstructed view of the photograph for the condition involving tracing at a distance.

Procedure

Rendering task. There were three drawing conditions in the rendering task: the tracing condition, the distance condition, and the traditional condition. In all of the conditions we asked the artists to draw the photograph as accurately as possible. We further instructed them that only the visual accuracy of the rendering was important and that we did not value aesthetics, style, or creativity. We explained visual accuracy as being photo realism (given the limits of the medium). Through the use of verbal examples, we explained aesthetic value, style, and creativity as being the creative abstractions similar to those of Picasso or Matisse. All of the artists appeared to fully understand the task.

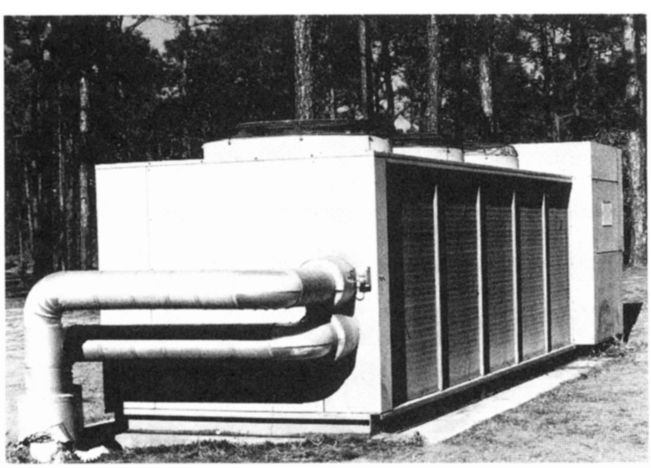

Figure 2. The photograph of the generator used in Experiments 1, 3, and 4. (Original was in color.)

Figure 3. The photograph of the face used in Experiments 1, 3, and 4. (Original was in color.)

We placed the transparency and photograph in different positions depending on the condition (see Figure 4). In the tracing condition, the photograph was taped underneath the top of the shelf; the transparency was taped ¼ in. (0.63 cm; the thickness of the plastic) above the photograph. In the distance condition, the photograph was taped to the table underneath the shelf; the transparency was taped on the shelf 12¼ in. (31.12 cm) above the photograph. In the traditional condition, the photograph was taped to the wall directly in front of the artist; the transparency was taped to the top of the shelf. A blank piece of paper was taped underneath the transparency to eliminate any possible interfering stimuli.

We tested the artists individually. In each drawing condition, four artists rendered the four photographs. Different artists participated in each drawing condition to eliminate carry-over effects. We allotted the artists 10 min to render each photograph. The 10-min allotment was sufficient because most artists indicated their completion at that time. We randomized the order in which the photographs were rendered. We interviewed the artists at the completion of the task about their formal and informal training in the visual arts.

Critics' task. In this task we used the renderings of the face and the generator that were produced in the rendering task (12 renderings of each photograph). We made photocopies of the transparencies to present the work as black marks against a white background and placed the renderings in clear plastic pouches to increase their durability. Half of the critics ranked the renderings on the basis of their visual accuracy, and half of the critics rated the renderings on the basis of their visual accuracy. We tested all critics individually.

[5] Throughout the article, the term *artist* refers to participants who generated the drawings. Unless otherwise stated, *artist* does not imply any level of rendering skill.

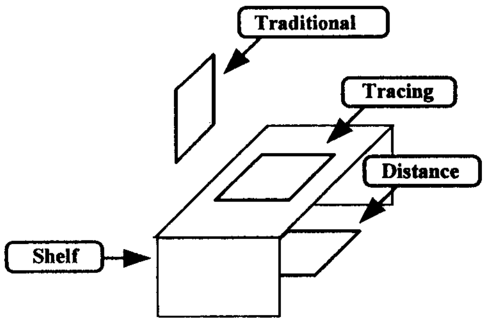

Figure 4. The positions of the transparency in the tracing, distance, and traditional conditions.

We asked 30 critics to *rank* the renderings on the basis of how closely the renderings approximated the photograph. We successively presented these critics with a packet of all the renderings of the face or a packet of all the renderings of the generator, along with the appropriate photograph. Both the order of presentation of the packets and the order of the renderings in the packets were randomized between critics. The ranking was accomplished by having the critics arrange the renderings from most accurate to least accurate.

We asked 30 different critics to *rate* the renderings on the basis of how closely the renderings approximated the photograph. We presented these critics with a packet of all 24 renderings (both of the face and of the generator), along with the two photographs. The order of the renderings in the packets was randomized between critics. The rating scale ranged from 1 (*very accurate representation*) to 10 (*very poor representation*). We permitted the critics to take as much time as they needed for each drawing, and when they were ready, they stated their response to each rendering.

We told all critics to make their judgments on the basis of the visual accuracy of the representation and not on the basis of aesthetic value, style, or creativity. We gave the critics the same explanation of visual accuracy that we had given the artists. All of the critics appeared to fully understand the task.

Results

Rank Data

The dependent variable was the critics' ranking of the renderings. The rankings ranged from 1 (*most accurate*) to 12 (*least accurate*). Although ranking was done on an ordinal measurement scale, we performed an analysis of variance (ANOVA) on the data. This is a valid statistical procedure because we transformed the rankings in the following way (Conover & Iman, 1981): (a) we found the mean ranking for each critic by photograph by drawing condition (e.g., the mean of critic A's ranking of all of the tracings of the face) and (b) for each photograph, we ranked those mean scores. We performed the ANOVA on the final ranks.

There was a significant main effect of drawing condition, $F(2, 58) = 393.91$, $p < .0001$, $MSE = 52{,}209$. Tukey's honestly significant difference (HSD) indicated that the critics ranked the renderings produced in the tracing condition ($M = 15.642$, $SD = 8.689$) as more accurate than those produced in the distance condition ($M = 46.233$, $SD = 9.562$), which they ranked as more accurate than those produced in the traditional condition ($M = 74.625$, $SD = 10.666$). The extreme differences in the rankings indicate that the participants almost universally considered the tracings to be more accurate renditions (a mean rank of 15.5 would indicate that every participant ranked every tracing as more accurate than the renderings in both other conditions). Because the participants ranked the renderings from different photographs separately, there was no possible main effect of photograph. There was no interaction between the drawing and the photograph conditions, $F(2, 58) = 0.0041$, $p = 1.0$, $MSE = 0.004$.

Rating Data

The dependent variable was the critics' rating of the renderings. The ratings ranged from 1 (*very accurate representation*) to 10 (*very poor representation*). We transformed the ratings by finding the mean rating for each critic by photograph by drawing condition and then ranking those mean scores. We performed an ANOVA on the final ranks. For ease of understanding, all summary statistics reported in Table 1 are in their raw form (untransformed).

There was a significant main effect of photograph, $F(1, 29) = 55.40$, $p < .0001$, $MSE = 44{,}274$. Critics rated the renderings of the generator as more accurate than those of the face. There was a significant main effect of drawing condition, $F(2, 58) = 319.31$, $p < .0001$, $MSE = 154{,}959$. Tukey's HSD indicated that the critics rated the renderings produced in the tracing condition as more accurate than those produced in the distance condition, which they rated as more accurate than those produced in the traditional condition. There was a significant interaction between the drawing and the photograph conditions, $F(2, 58) = 5.69$, $p = .0056$, $MSE = 2{,}006$; the renderings of the face showed a more shallow decrease in accuracy in the traditional condition than did the renderings of the generator (see Figure 5). This interaction was probably the result of a ceiling effect.

Table 1
Summary Statistics of Critics' Ratings of Renderings for Each Photograph, Drawing Condition, and Photograph × Drawing Condition

Drawing condition	Photograph: Face *M*	Face *SD*	Generator *M*	Generator *SD*	Main effect of drawing *M*	*SD*
Tracing	4.08	2.34	2.68	1.62	3.38	2.12
Distance	7.08	2.22	5.01	2.51	6.04	2.58
Traditional	8.64	1.73	7.60	2.03	8.12	1.96
Main effect of photograph	6.60	2.83	5.10	2.89		

Note. Lower numbers indicate more accurate representations.

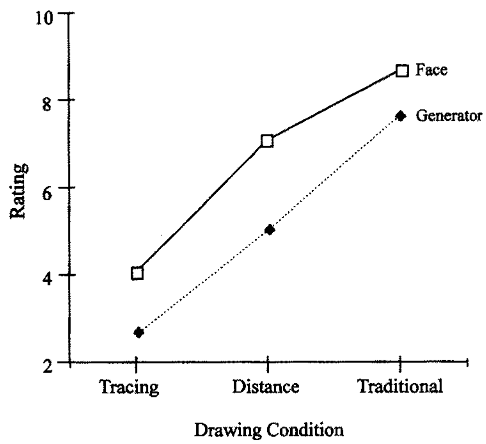

Figure 5. The critics' ratings of the artists' renderings of the two photographs in the three drawing conditions.

Discussion

The results indicate that almost universally, the renderings in the tracing condition were more accurate than the renderings in the distance condition, which in turn were more accurate than the renderings in the traditional condition. Figure 6 shows typical examples of renderings in the tracing and the traditional conditions. Overall, participants rated the tracings as quite accurate representations, whereas they rated the traditional renderings as quite poor representations. The accuracy of the tracings indicates that the artists were adept at both making representational decisions and at motor coordination. Despite those skills, the artists were unable to accurately represent the photographs in the traditional condition. Thus, the grossest drawing inaccuracies were the result of the artists' misperceptions of the object or of their drawing.

The rating results also indicate that the artists rendered the generator better than they rendered the face, regardless of the drawing condition. Because the artists' reduced ability to accurately render the face was found in the tracing condition, these drawing inaccuracies were probably the result of poor representational decisions, deficient motor skills, or both. Representational decisions may be more difficult when rendering the face because faces lack the sharply defined features present in the photograph of the generator. Simply outlining the intensity edges of the gen-

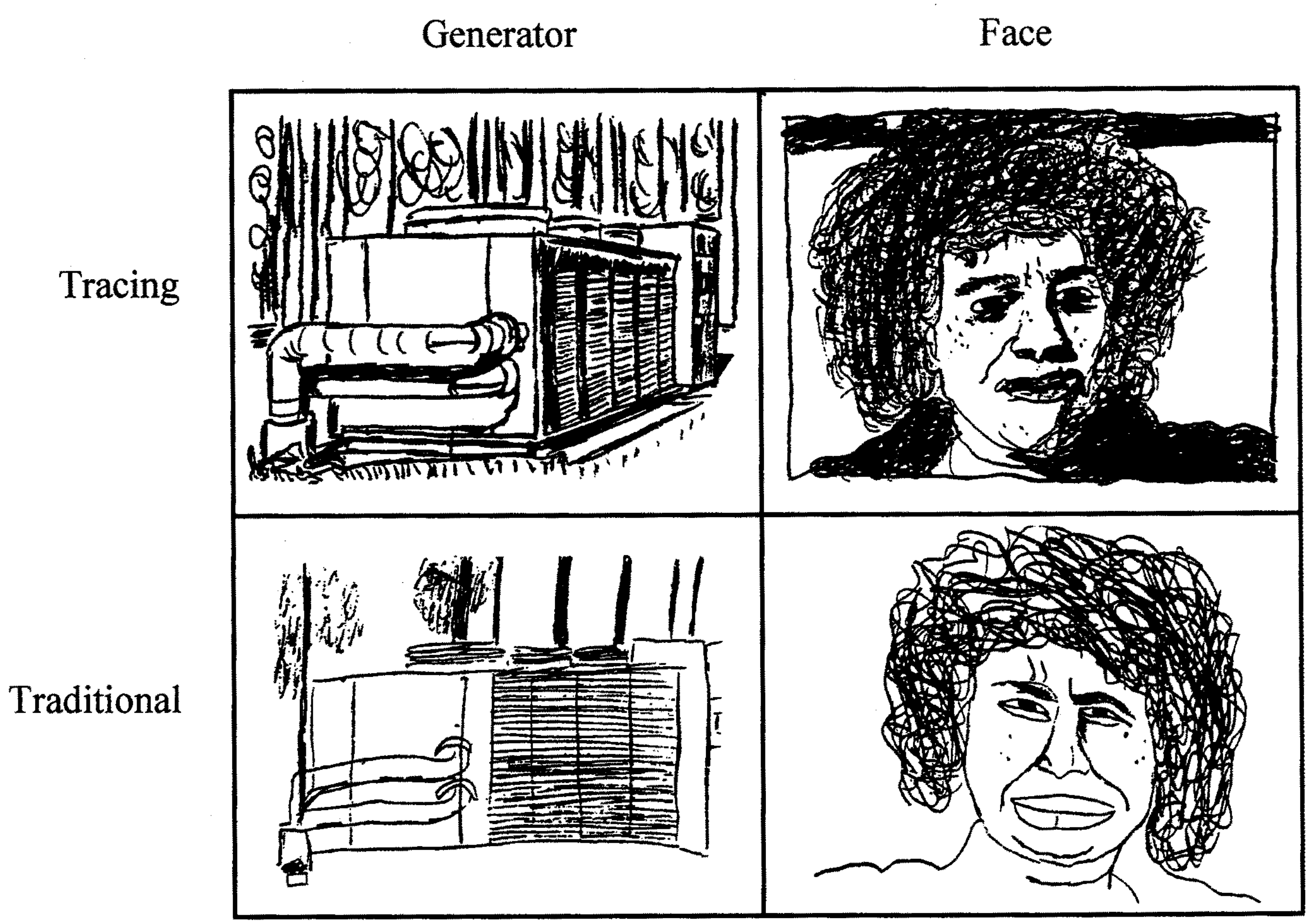

Figure 6. Typical examples of renderings of the face and the generator in the tracing and the traditional conditions.

erator produces an accurate representation. Simply outlining the intensity edges in the photograph of the face does not produce an accurate representation. To accurately represent the features of the face, the artist also must convey the blending of features. This requires lines of different widths and intensities (simple monotone lines adequately represent the generator). The artists may not have had the ability to create the variety of marks needed to convey the blending of features. Thus, artists' errors in rendering the face may have resulted both from poor representational decisions and/or an inability to translate those decisions into physical marks.

The results of the distance condition are difficult to interpret. We originally included this condition to remove the effect of memory from the traditional condition because the photograph was always in sight. However, this condition had the potential to maintain the advantages of the tracing condition. If an artist closed one eye and kept his or her head still, then this condition was identical to the tracing condition. The distance drawings were probably ranked intermediately because the artists could have treated this condition as either a tracing condition, a traditional condition, or a hybrid. Because we cannot determine what the artists were doing, we cannot assess the effect of that performance.

In summary, the artists' ability to create visually accurate renderings in the tracing condition and their inability to create visually accurate renderings in the traditional condition suggest that the largest source of the drawing inaccuracies was the artists' inability to accurately perceive the object, their drawing, or both. However, the artists' ability to render the generator more accurately than the face indicates that poor representational decisions and deficient motor skills may have been minimal sources of drawing inaccuracies. To further explore this finding, we conducted a second experiment. In Experiment 2 we attempted to separate the cognitive effect of the representational decisions from the physical effect of making a mark.

Experiment 2

In Experiment 2 we asked artists to trace a tracing of the face and the generator. To successfully trace a tracing, the artists needed only to possess the ability to mimic the mark of another. Thus we simplified the tracing task of Experiment 1 by eliminating the need for the artists to make representational decisions. We asked independent critics to rank the tracings on the basis of accuracy. If the artists' motor abilities were not factors in drawing inaccuracies, then the mean rank of the tracings of the face should equal the mean rank of the tracings of the generator.

Method

Participants

Nine students volunteered to participate as artists. No artist had formal training in the visual arts. Twenty-nine students volunteered to participate as critics, whom we recruited individually at the university library. We did not assess the critics' formal training in the visual arts; however, we assumed that if a critic had any formal training, it was minimal.

Materials

We used the highest rated tracing of the face (mean rating = 2.34) and the generator (mean rating = 2.20) as stimuli in the rendering task (see Figures 7 and 8). The ratings did not significantly differ, $t(59) = 0.43$ (*ns*). We placed the tracings in standard 8 × 10 in. (20.32 × 25.40 cm) frames covered by a thin piece of glass.

In the rendering task, artists used a black wax pencil on clear transparencies. The transparencies were placed on top of the glass, inside the frame.

We used photocopies of the artists' nine renderings of the face and nine renderings of the generator as the stimuli in the critics' task. We placed these copies in clear plastic pouches to increase their durability. We also gave the critics the same framed tracings that the artists had used as standards in the rendering task.

Procedure

Rendering task. We tested the artists individually. We presented them with the framed tracing and asked them to trace the tracing as accurately as possible. We gave the artists the same instructions and 10-min allotment that we had given the artists in Experiment 1. We randomized the order in which the tracings were rendered.

Critics' task. We tested the critics individually. We presented them with a packet of all 18 renderings (both of the face and of the generator) and the 2 standards (the framed tracings). The order of the renderings in the packets was randomized between critics. We asked the critics to rank the renderings on the basis of how closely they approximated the standard. We gave the critics the same instructions that we had given the critics in Experiment 1.

Results

We used ranking as the dependent measure because it forced participants to make subtle distinctions (all of the tracings appeared to be very accurate representations). Rankings ranged from 1 (*most accurate*) to 18 (*least accu-*

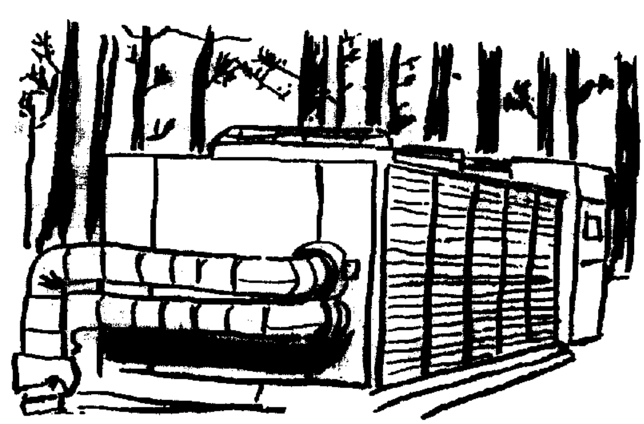

Figure 7. The tracing of the generator used as the standard in Experiments 2 and 3.

Figure 8. The tracing of the face used as the standard in Experiments 2 and 3.

rate). As we had done in Experiment 1, we transformed the data by finding the mean ranking for each critic by photograph and then ranking those mean scores. We performed an ANOVA on the final ranks. For ease of understanding, all reported summary statistics are untransformed.

There was a significant effect of image traced, $F(1, 28) = 8.37$, $p = .007$, $MSE = 3{,}728$. The critics ranked the tracings of the generator ($M = 9.04$, $SD = 4.99$) as more accurate than those of the face ($M = 9.96$, $SD = 5.37$).

Discussion

The results show that the artists traced the tracing of the generator more accurately than they traced the tracing of the face. Because the task of tracing requires only that the artists have the physical ability to mimic the mark of another, this result indicates that there is a physical component to drawing inaccuracies. It is unlikely that this physical component involves the artists' inability to mimic curvature because to create an accurate tracing of the generator, the artists must draw lines at varying degrees of curvature and around ragged features (e.g., outlining the trees and leaves). It is more likely that the physical component involves the subtle variation in the quality of the marks present in the standard of the face. These different line styles were not present in the standard of the generator. A review of the artists' tracings indicated that the artists used one style of line: a single thickness and intensity. The artists may have lacked sufficient knowledge of the range of marks that a pencil can make. Alternatively, the artists may simply not have understood the importance of mimicking the line style as well as the line position and thus did not attempt to do so.

Although this experiment reveals that knowledge of how to mimic a mark may be a likely contributor to drawing inaccuracies, the contribution is slight: Critics ranked the tracings of the face and of the generator around the true mean (9.5). This result suggests that the artists' deficiency in tracing the face in Experiment 1 was largely due to a deficit in the artists' ability to make good representational decisions and minimally to a deficit in the artists' physical abilities to produce different line styles.

Together, Experiments 1 and 2 suggest that the grossest drawing inaccuracies are not the result of representational decisions or motor coordination. We conducted Experiment 3 to provide converging evidence for this conclusion.

Experiment 3

If representational decisions are only a minor source of drawing inaccuracies, then the removal of the need for the artist to make representational decisions should have little effect on the overall quality of the drawing. By having an artist copy a tracing of a photograph, we created a situation in which the artist must use all of the drawing abilities except that of making representational decisions. Therefore, the artist's copy of a tracing of a photograph should be of approximately equal quality to the artist's rendering of that photograph. In Experiment 3 we tested this hypothesis by having artists render in the traditional condition the tracings used as standards in Experiment 2 and the original photographs on which those tracings were based. On the basis of the results of Experiment 1, we predicted no difference between the renderings from the photograph and the renderings from the tracings of the generator; we predicted a small difference between the renderings from the photograph and the renderings from the tracings of the face.

Method

Participants

Twelve students volunteered to participate as artists. No artist had formal training in the visual arts. Thirty students volunteered to participate as critics, whom we recruited individually at the university library. We did not assess the critics' formal training in the visual arts; however, we assumed that if a critic had any formal training, it was minimal.

Materials

We used the tracings that had been used as standards in Experiment 2 and the original photographs as stimuli in the rendering task. In the rendering task, artists used a #2 pencil on standard 8.5 × 11 in. (21.59 × 27.94 cm) paper. All stimuli were positioned as they had been in the traditional condition in Experiment 1.

We used photocopies of the artists' 12 renderings of the face and 12 renderings of the generator as the stimuli in the critics' task. We placed these copies in clear plastic pouches to increase their durability. We also gave the critics the original photographs.

Procedure

Rendering task. We tested the artists individually. Each artist rendered two images: one of the face and one of the generator. One of these images was a tracing and one was a photograph (counterbalanced between artists). The order of the image rendered was counterbalanced between participants. We gave the artists the same instructions and 10-min allotment that we had given the artists in Experiment 1.

Critics' task. We tested the critics individually. We presented them with a packet of all 24 renderings (both of the face and of the generator) and the 2 photographs. The order of the renderings in the packets was randomized between critics. We gave the critics the same instructions that we had given the critics in Experiment 1 and asked them to rate the renderings on the basis of how closely the renderings approximated the photograph. The rating scale ranged from 1 (*very accurate representation*) to 10 (*very poor representation*). We permitted the critics to take as much time as they needed for each drawing, and when they were ready, they stated their response to each rendering.

Results

The dependent variable was the critics' rating of the renderings. Ratings ranged from 1 (*very accurate representation*) to 10 (*very poor representation*). As we had done in Experiments 1 and 2, we transformed the data by finding the mean rating for each critic by standard (tracing or photograph) and image (face or generator) and then ranking those mean scores. We performed an ANOVA on the final ranks. For ease of understanding, all summary statistics reported in Table 2 are untransformed.

There was a significant main effect of image, $F(1, 29) = 12.01$, $p = .002$, $MSE = 15{,}870$; the critics rated the renderings of the generator as more accurate than those of the face. There was a significant main effect of standard, $F(1, 29) = 9.16$, $p = .005$, $MSE = 2{,}134$; the critics rated the renderings of the tracings as more accurate than those of the photographs. Note that there was a significant interaction between the type of standard and the image, $F(1, 29) = 19.37$, $p < .001$, $MSE = 3{,}853$. Further analysis revealed that the renderings of the tracing of the generator and the photograph of the generator were not significantly different, $F(1, 59) = 0.12$, $p = .73$, $MSE = 126$. However, the renderings of the tracing of the face and the photograph of the face were significantly different, $F(1, 59) = 5.51$, $p = .02$, $MSE = 5{,}861$.

Discussion

The results show that when the artists copied a tracing of the generator, the copies were no more accurate than when the artists copied directly from the photograph of the generator. Because copying a tracing only removed the need to make representational decisions, poor representational decisions did not contribute to drawing inaccuracies. Compared with the artists' copies of the photograph of the face, their copies of a tracing of the face showed minor improvement. This supports the results of Experiment 1 that poor representational decisions contributed minimally to drawing inaccuracies when copying the photograph of the face.

Experiments 1, 2, and 3 provide substantial evidence that motor coordination and representational decision-making abilities do not significantly contribute to drawing inaccuracies. The grossest drawing inaccuracies must thus be the result of the artists' misperceptions of either the object or their drawing. We conducted Experiment 4 to assess whether artists have a misperception of their own drawings.

Table 2
Summary Statistics of Critics' Ratings of Renderings for Each Image (Face or Generator), Standard Type (Tracing or Photograph), and Image × Standard Type

	Image				Main effect of standard type	
	Face		Generator			
Standard type	*M*	*SD*	*M*	*SD*	*M*	*SD*
Tracing	5.55	2.32	5.04	2.68	5.30	2.52
Photograph	6.43	2.62	4.86	2.58	5.65	2.72
Main effect of image	6.00	2.51	4.95	2.63		

Note. Lower numbers indicate more accurate representations.

Experiment 4

In this experiment, we asked artists of varying abilities to draw the two photographs in the traditional orientation. We then gave the artists a magnitude estimation task that involved estimating the visual accuracy of representation of both their drawings and others' drawings. We also asked independent critics to estimate the visual accuracy of those same drawings. We compared these estimates to determine if there were any systematic variations. If artists misperceive their own drawings, then the degree to which the artists overestimate the accuracy of their drawings (as compared with the critics' estimate of those same drawings) should be negatively correlated with artistic skill (termed the *accuracy bias* hypothesis). Furthermore, we should not find this same pattern when the artists estimate the accuracy of the drawings of others.

Method

Participants

Twenty-eight students from the general psychology participant pool volunteered to participate as artists (median months of art education = 0). Eleven art majors volunteered to participate as artists from an advanced drawing class (median months of art education = 12). Throughout Experiment 4, the term *artists* refers only to the 39 artist–participants in this experiment and not to the artist–participants of Experiment 1.

One hundred and fifty-six students volunteered to participate as critics, whom we recruited individually at various locations around the university. We did not assess the critics' formal training in the visual arts; however, we assumed that if a critic had any formal training, it was minimal.

Materials

We used the same 6 × 8.5 in. (15.24 × 20.32 cm) color photographs of the face and the generator as stimuli in this rendering task that we had used in Experiments 1 and 3. The artists used a black wax pencil on standard 8.5 × 11 in. (21.59 × 27.94 cm) paper.

In the magnitude estimation task, we used 7 of the 12 renderings of the face and 7 of the 12 renderings of the generator that had been created by participants in Experiment 1. The renderings chosen represented an even distribution of accuracy of rendition as judged by the critics in Experiment 1. We chose the rendering that had the median ranking, as judged by the critics in Experiment 1, as the standard.

Procedure

Rendering task. We tested the artists individually. The stimuli were positioned as they had been in the traditional condition in Experiment 1. We gave the artists the same instructions and 10-min allotment that we had given the artists in Experiment 1. The artists rendered the images in both photographs; the order in which the photographs were rendered was randomized between artists.

After each artist completed both drawings, we gave the artist the magnitude estimation task (Stevens, 1956). The renderings of the face and the generator were judged separately. We first presented the artist with the renderings of the photograph that the artist drew first. The order of the six renderings chosen from Experiment 1 and the artist's rendering was randomized. We told the artist to assess the accuracy of the renderings compared with the photograph and advised the artist not to make his or her assessments on the basis of aesthetic value, style, or creativity. We then presented the artist with both the standard and the photograph. The standard was assigned the number 1,000. The artist was to determine the degree to which each rendering accurately represented the photograph as compared with the degree that the standard represented the photograph and to proportionately assign a number to that drawing. For example, if the drawing was twice as accurate as the standard, the artist was to assign it a value of 2,000. If the drawing was two thirds as accurate as the standard, the artist was to assign it a value of 666, and so on.

Critics' task. We tested the critics individually. Each critic participated in the magnitude estimation task described above for both the face and the generator renderings. For each critic, we prepared two packets of renderings (one of renderings of the face and one of renderings of the generator) such that each contained the appropriate photograph, the standard, the six renderings chosen from Experiment 1, and, randomly, one artist's rendering from the above task. We placed all of the renderings in clear plastic pouches to increase their durability. Both the order of presentation of the packets and the order of the renderings in the packets were randomized between critics. We gave the critics the same instructions as described above. Each of the renderings produced by the artists was judged by four different independent critics.

Results

To obtain a measure of the discrepancy between the artists' estimations (*e*Artist) and the critics' estimations (*e*Critic), we transformed the data in the following way: log (*e*Artist/*e*Critic). This transformation (termed *discrepancy ratios*) eliminates drawing accuracy as a factor and only represents the degree of disparity between each artist's estimation and the critic's estimation. A score of zero indicates that the critic and the artist agreed on the accuracy of representation of the drawing, a score below zero indicates that the artist estimated the drawing to be a less accurate representation than the critic did, and a score above zero indicates that the artist estimated the drawing to be a more accurate representation than the critic did.

Four critics estimated the accuracy of each artist's drawing. For each artist, we calculated two independent *e*Critics (*e*CriticA and *e*CriticB). We calculated each *e*Critic by converting two of the critics' estimates into logs and computing the antilog of the mean of those logs. The conversion was taken because magnitude estimates follow a power function. We chose different critics' estimates to calculate each *e*Critic. We used *e*CriticA in the calculation for the discrepancy ratios and *e*CriticB as a measure of artistic skill. We calculated these independent *e*Critics to assure independence between the discrepancy ratios and measures of skill in all statistical analyses.

We performed a three-way ANOVA on the discrepancy ratios as predicted by training (trained–untrained), photograph (face–generator), and drawing (self–others). Although there was a significant overall effect, $F(1, 387) = 4.56$, $p = .03$, $MSE = 0.47$, there were no other significant effects (see Table 3). This indicates that artists in general overestimated all of the renderings, regardless of who created those renderings ($M = 0.06$, $SD = 0.42$).

Because the artistic skill of the untrained participants overlapped with those of the trained participants, we split the data on the basis of skill as measured by log (*e*CriticB).

Table 3
Means and Standard Deviations for log eCritic$_{artist}$ and Drawings (Self and Others) by Artistic Skill and Training

			Discrepancy ratios					
	log *e*Critic$_{artist}$		Self drawings			Others' drawings		
Condition	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
Artistic skill								
Low	2.23	0.23	15	0.13	0.39	88	−0.05	0.43
Medium	2.75	0.14	45	0.16	0.46	269	0.09	0.43
High	3.12	0.06	18	0.001	0.37	108	0.06	0.39
Artistic training								
Trained	2.96	0.21	22	0.18	0.35	132	0.10	0.46
Untrained	2.65	0.32	56	0.90	0.46	333	0.40	0.41

Note. *e*Critic$_{artist}$ = critics' estimations of artists' renderings.

We created three levels of skill: low, log (eCriticB$_{artist}$) < 2.45; medium, $2.45 \geq$ log (eCriticB$_{artist}$) ≤ 3.0; and high, log (eCriticB$_{artist}$) > 3.0. We used a three-way ANOVA on the discrepancy ratios as predicted by skill (high–medium–low), photograph (face–generator), and drawing (self–others). Aside from the overall effect described above, there were no significant effects (see Table 3). In addition, there was no significant correlation between artistic skill (measured by eCriticB$_{artist}$) and the discrepancy ratio for the artists' renderings of the face ($r = .01$, *ns*) and generator ($r = -.2$, *ns*).

Discussion

We used discrepancy ratios to assess the artists' abilities to detect drawing inaccuracies in their work. We assumed that artists who overestimated the accuracy of their work detected fewer inconsistencies between their work and the standard, relative to independent observers. Similarly, artists who underestimated the accuracy of their work detected more inconsistencies between their work and the standard, relative to independent observers.

The results failed to support the hypothesis that artists systematically misperceive their renderings. Both skilled and unskilled artists overestimated the accuracy of renderings regardless of who created the rendering. This general but small overestimation of all work may be attributed to the artists' recognition of the attempts made by other artists to faithfully represent the photographs. In their attempts to draw the photographs, all of the artists were forced to make similar decisions. Therefore the artists may have recognized what the critics may have missed: the intent behind the marks in both the artist's renderings and others' renderings. An understanding of the intent behind a mark may translate into a higher estimation of the accuracy of the rendering. This effect was small and unrelated to artistic ability.

In summary, this experiment provides no evidence that artists are affected by an accuracy bias. Therefore, artists' accuracy biases do not contribute to the artists' inability to draw what they see. However, as with all quasi-experimental designs, caution must be taken when interpreting the results. Although the data suggest that artists do not demonstrate an accuracy bias with respect to their renderings, more experiments are needed to confirm this conclusion.

General Discussion

We began this article with the question, Why can't most people draw what they see? We analyzed the drawing process and presented four possible sources of an artist's drawing inaccuracies: (a) misperception of the object, (b) inability to make good representational decisions, (c) lack of adequate motor coordination, and (d) misperception of his or her work. We conducted four experiments that assessed the degree to which the latter three sources contributed to drawing inaccuracies.

The results of Experiments 1 and 2 show that the artists' lack of motor coordination was a very minor contributor to drawing inaccuracies. Artists could produce very accurate representations by tracing a photograph. There was a small deficit in the artists' ability to trace a tracing of the face. This may have resulted from the artists' inability to produce the variety of marks needed to convey blending. This deficit was probably more the result of the artists' insufficient knowledge of the mark-making instrument than of inadequate motor coordination. The minimal effect of motor coordination is not surprising because the coordination skills needed to render an object with a pencil are similar to those needed to write a letter or to draw a map. These skills are acquired in this culture at an early age. Thus, most adults possess the motor coordination needed to render accurate representations.

The results of Experiments 1 and 3 show that the artists' inability to make representational decisions minimally contributes to drawing inaccuracies. The artists could render more accurate representations when the features in the photograph were sharply defined than when they were not. However, the artists were still quite competent at making representational decisions when confronted with blended features (the face condition). Thus, the artists' decision process is not a major contributor to drawing inaccuracies.

On the surface, this finding may seem to contradict Gombrich's theory (1984) that drawing inaccuracies are a result of the artist not knowing the tricks of drawing. However, Gombrich made his argument on historical grounds, arguing that the tricks of drawing have changed between generations. Within generations, critics have been satisfied with the quality of the realism portrayed. Just as the makeup used by actors in horror movies of the 1950s satisfied the audiences at that time, the cosmetic tricks used by actors today make the earlier effects now seem unsatisfactory. The artists in Experiment 1 made good representational decisions for the zeitgeist. As Gombrich predicted, these lay artists probably learned the tricks of drawing from viewing other pictures. Therefore, the relatively small effect of decision-making skills on drawing inaccuracies is probably the result of the general population already possessing the knowledge of the culturally correct way to simplify a visual scene.

The conclusion that representational decisions are not a major source of drawing inaccuracies should be tempered by the knowledge that photographs were used as stimuli. Because the image was already a projection onto a two-dimensional surface, some difficulties associated with the translation of a three-dimensional object into two dimensions were curtailed. It has been argued that the translation of an object from three dimensions to two dimensions is the source of the most difficult representational decisions (Richter, 1970).[6] Therefore, our conclusion is restricted to the representational decisions made by the artists when presented with the color photographs. It should be noted, however, that drawing the image in a photograph is not an

[6] We are currently conducting research to test this assumption.

easy task, as can be seen by the poor quality of the renderings in the traditional condition.

Finally, the results of Experiment 4 suggest that artists do not selectively misperceive their work as more accurate than it actually is. Both skilled and unskilled artists overestimated the accuracy of all renderings, regardless of who created the rendering. Because there is no systematic bias related to artistic skill, this misperception cannot be a source of drawing errors.

Considered together, these results imply that the artists' misperception of the object is the major source of drawing errors. Previously, we differentiated between two possible sources of object misperception: illusion and delusion. Most of the drawing errors were probably not the result of the effects of illusion because both skilled and unskilled artists were affected by illusions. Therefore, delusion, as defined earlier, may be the major source of adult drawing errors. Empirical results, however, are needed to support this hypothesis.

In sum, this series of experiments provides evidence that (a) the artist's motor coordination is a minimal source of drawing inaccuracies, (b) the artist's decision-making process is a relatively minor source of drawing inaccuracies, and (c) the artist's misperception of his or her work is not a source of drawing inaccuracies. These results suggest that the artist's misperception of the object is a major source of drawing errors. These experiments only begin to assess why people cannot draw what they see. Many areas of this problem are still unresolved or have yet to be defined. For instance, although the data suggest that an artist's misperception of the object is a major contributor to drawing inaccuracies, a direct relationship has yet to be established. However, as the Chinese point out, the spirit is in the movement.

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