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The Effect of Object Interpretation on the Appearance of Drawings of Ambiguous Figures

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We studied how the appearance of observational drawings is affected by how individuals interpret the model object they are copying. Participants were asked to draw 2 ambiguous figure models (Fisher's *Gypsy/Girl with Mirror* and *Man/Girl* figures). Before being exposed to the models, participants were randomly assigned to receive 1 of the 2 possible interpretations of the figures during the task instructions. After all the drawings were completed, a group of independent judges rated the appearance of the drawings with respect to what object they thought the drawing was trying to depict. Analysis of the ratings indicated that the ambiguous figure interpretations provided to participants during the task instructions affected the ultimate appearance of their drawings. For the most part, participants' drawings were biased to appear more like the object that was the subject of the interpretation they received during the task instructions than the alternative possible interpretation they did not receive. These results demonstrate that the categorization of model objects affects the ultimate appearance of drawings of that model. This supports the general perspective that top-down processes affect observational drawings beyond the bottom-up encoding of the visual information inherent in a model. The possible mechanisms producing this effect are discussed.

Keywords: observational drawing, ambiguous figures, graphic production, object categorization, top-down

Observational drawing is the behavior where individuals attempt to draw a model stimulus with the goal of producing a recognizable depiction of the specific model. Because this behavior begins with visually perceiving the model to be drawn, it has been theorized that individual variability in the appearance of drawings depicting a standard model is related to individual differences in the perceptual encoding of the model (e.g., Cohen & Bennett, 1997). This general perspective has received empirical support (e.g., Cohen, 2005; Cohen & Jones, 2008; Mitchell, Ropar, Ackroyd, & Rajendran, 2005; Ostrofsky, Cohen, & Kozbelt, 2014; Ostrofsky, Kozbelt, & Cohen, 2015; Perdreau & Cavanagh, 2014; Tchalenko, 2009). However, observational drawing is a complex behavior that is guided by cognitive processes that extend beyond the bottom-up processing of the visual information found in a model. There are multiple top-down processes that affect the production and ultimate appearance of a drawing, such as decision-making and attentional processes that guide the selection of what features are included in and excluded from a depiction (Biederman & Kim, 2008; Kozbelt, Seidel, ElBassiouny, Mark, & Owen, 2010; Kozbelt, Snodgrass, & Ostrofsky, 2014; Ostrofsky, Kozbelt, & Seidel, 2012), the activation of long-term memories that represent the graphic properties of familiar objects (Matthews & Adams, 2008; Ostrofsky, 2015), and one's use of their declarative knowledge pertaining to the canonical proportions of common objects (Ostrofsky, Kozbelt, Tumminia, & Cipriano, 2016).

Extending the latter point, much research has been conducted to determine how categorization of model objects affect the production and ultimate appearance of drawings (Allen & Chambers, 2011; Carmichael, Hogan, & Walter, 1932; Glazek, 2012; Phillips, Hobbs, & Pratt, 1978; Sheppard, Ropar, & Mitchell, 2005; Van Sommers, 1984; Vinter, 1999). Most of these studies have provided evidence suggesting that the recognition (or, lack thereof) of an object's identity affects the ultimate appearance of drawings, presumably due to an activation and influence of long-term memories that represent the category the model-object belongs to.

For instance, some studies have compared the accuracy of drawing objects belonging to familiar, recognizable categories (e.g., trucks, televisions, wine glasses) versus objects that do not belong to recognizable categories (e.g., abstract patterns, logograms of an unfamiliar language; Glazek, 2012; Phillips et al., 1978; Sheppard, Ropar, & Mitchell, 2005). These studies have provided mixed evidence relating to the impact that an individual's familiarity with a model object has on drawing production. Studies by Glazek (2012) and Phillips, Hobbs, and Pratt (1978) suggest that familiarity with an object negatively impacts drawing performance, as models representing familiar objects were found to be drawn less

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accurately than unfamiliar model objects. However, a major limitation of these two studies was that the difference in familiarity between the models was confounded with their apparent dimensionality. For the most part, the familiar models contained three-dimensional (3D) cues and the unfamiliar models did not. Improving on this, Sheppard, Ropar, and Mitchell (2005) conducted a factorial experiment that compared drawing accuracy between depictions of familiar and unfamiliar model objects that were presented with and without 3D cues. Overall, drawings of models with 3D cues were found to be less accurate than drawings of models without 3D cues. Additionally, when 3D cues were present, accuracy did not differ between the drawings of familiar and unfamiliar models, suggesting that the results of Glazek (2012) and Phillips et al. (1978) were produced by the effects of the models' dimensionality rather than the participants' level of familiarity with the model. Interestingly, when 3D cues were absent, familiar models were drawn more accurately than unfamiliar models. However, despite controlling for the dimensionality and the number of lines included in the familiar and unfamiliar models, they still differed in appearance, resulting in differences with respect to other visual aspects of the stimuli (e.g., aspect ratio and number of angles). This could have affected drawing accuracy in a way that potentially had nothing to do with the degree of familiarity that participants had with the identity of the model objects.

Thus, comparing the drawing accuracy of familiar versus unfamiliar models may not be an ideal methodological strategy for testing whether one's interpretation of an object's identity affects the ultimate appearance of drawings. The necessary differences in appearance between familiar and unfamiliar models makes it difficult to tease apart whether differences in drawing accuracy has been caused by differences in the degree of familiarity participants had with the model object, differences in the visual appearance of the models, or some combination of both.

In order to improve on this limitation, it would be advantageous to assess the effects of model interpretation on the appearance of drawings by assessing the drawings of stimuli that are equated in appearance but differ in interpretation of the model object's identity. One way this can be achieved is in studying the drawings of ambiguous figures. An ambiguous figure, such as the famous *duck/rabbit* figure, is a single stimulus that can be visually recognized to depict one of at least two different objects. The ambiguity of such figures are highlighted by observations that, at least for some figures, there is a random distribution of the interpretation first perceived by individuals upon initial exposure to the stimulus (e.g., Fisher, 1967a, 1967b). Interestingly, the initial interpretation recognized by individuals can be biased toward a particular interpretation by processing information prior to the initial exposure of the ambiguous figure, such as through perceptual priming (e.g., being shown an unambiguous version of the figure that emphasizes one interpretation over another) and conceptual priming (e.g., being exposed to written passages that semantically relate to one of the possible interpretations; being shown a set of images that depict objects which are semantically related to one of the possible interpretations; Balcetis & Dale, 2007; Bugelski & Alampay, 1961; Goolkasian, 1987).

Thus, ambiguous figures may be an ideal type of stimuli that can be used as a tool to assess the effects of object interpretation on the appearance of drawings. Specifically, one may be able to assess how the appearance of a drawing of an ambiguous figure is affected when the participants' initial interpretation of the figure is biased by receiving information before they are exposed to the figure and begin to draw it. This methodological strategy has been adopted in prior drawing research (Allen & Chambers, 2011; Carmichael et al., 1932; Van Sommers, 1984; Vinter, 1999). For instance, ambiguous figures presented in conjunction with a written caption that describes one of the possible interpretations affects the sequence of marks made by participants when asked to draw the figure (Van Sommers, 1984; Vinter, 1999). This demonstrates that one's interpretation of a model object can affect the sequential process of producing a drawing.

Other research aimed to determine if providing participants one of the possible interpretations of an ambiguous figure before being asked to draw it affected the drawing's ultimate appearance (Allen & Chambers, 2011; Carmichael et al., 1932). In an early study, Carmichael, Hogan, and Walter (1932) exposed participants to and asked them to draw multiple ambiguous figures. Before being exposed to the ambiguous figures, the participants were randomly assigned to receive one of the two possible interpretations of the figure's identity in the task instructions. After all of the drawings were generated, two judges rated the drawings with respect to their appearance. Analysis of these ratings led the researchers to conclude that the appearance of the drawings was affected by the interpretation of the figure that was provided to them in the task instructions, as they reported evidence that seemingly demonstrated that the drawings appeared more like the object that was the subject of the interpretation provided in the instructions than the alternative interpretation not provided in the instructions. However, a number of limitations prevents the results of this study from supporting a strong conclusion that one's interpretation of an object affects the appearance of their drawings. First, this study employed only two judges to rate the appearance of the drawings, and these two judges were both coauthors of the study. This presents two potential problems: (a) it is difficult to establish the generalizability of ratings when only two judges provide them, and (b) the personal interest the coauthors had in the study may have intentionally or unintentionally biased their ratings. Second, the conclusions the researchers offered were based on the analysis of the appearance ratings for only 26% of all the drawings produced in the study. This minority represented the drawings that were previously rated by the coauthors/judges to be "completely changed from the original (figure being copied)" (p. 77). This analytical strategy makes it difficult to gauge how generalizable the results are to the larger population, as we have no concrete knowledge pertaining to how 74% of the drawings were affected by the interpretation of the ambiguous figure the participants were provided before drawing. As will be explained later, the current study partially aims to improve on these two limitations.

A later study by Allen and Chambers (2011) was performed with similar aims. Here, autistic and nonautistic (but learning disabled) adolescents were exposed to four ambiguous figures and were asked to draw them twice. With respect to the first time they drew the figures, the participants were provided one of the possible interpretations in the task instructions in what was termed the "Label Condition" for two of the four ambiguous figure stimuli (e.g., participants were randomly assigned to be instructed to "draw this rabbit" or "draw this duck"). For the other two ambiguous figures, the participants were not provided an interpretation during the task instructions in what was termed the "Non-Label

Condition" (e.g., participants were instructed to "draw this picture"). After completing the initial drawing, the participants were asked to draw the ambiguous figures again (in the "Label Condition," they were provided the alternative interpretation in the task instructions relative to the interpretation provided during the instructions for the first drawing; in the "Non-Label Condition" they were simply asked to "draw this picture again"). After the drawings were collected, an independent judge was shown all of the pairs of drawings each participant produced for each of the four ambiguous figure models. For each pair, the judge was asked to rate how similar the two drawings were to each other. With respect to the nonautistic participants, the two drawings of the ambiguous figures in the "Label Condition" were rated, on average, as less similar than the two drawings of the ambiguous figures in the "Non-Label Condition." In contrast, the similarity ratings of the two drawings of each figure produced by the autistic participants did not differ, on average, between the "Label" and "Non-Label" conditions.

The authors used this evidence to conclude that being provided labels that indicate one of the possible interpretations of the ambiguous figures biases the appearance of drawings produced by nonautistic participants, but not for autistic participants. However, the method of this study contains multiple limitations that prevent it from providing strong evidence that stimulus interpretation affects the appearance of drawings of ambiguous figures. The first major limitation was that the similarity ratings used as the dependent measure of the drawings are unclear in terms of what they mean about the appearance of the drawings and how they were affected by the provided interpretations in the "Label Condition." For example, if a pair of drawings of a single ambiguous figure were rated to be dissimilar, it is unclear as to whether they are dissimilar with respect to the object being depicted (e.g., one drawing appears to be of a duck while the other appears to be of a rabbit) or whether they are dissimilar just with respect to the appearance of the drawing (e.g., both drawings appear to be of a duck, but they just look different from each other). As another example, if a pair of drawings of a single ambiguous figure in the "Label Condition" was rated to be similar, this does not necessarily mean that the drawings were not affected by the interpretation provided in the task instructions. Alternatively, this could mean that participants were extremely biased by the first interpretation they were provided in the instructions of the first drawing and were unable to overcome this bias when provided the alternative interpretation during the instructions of the second drawing.

Similar to a major limitation of the Carmichael et al. (1932) study, Allen and Chambers (2011) employed only one judge to provide similarity ratings for all of the pairs of drawings (although, a second rater provided ratings for 25% of the drawing pairs, and the correlation in ratings between the two judges were $r = +.88$). Having one judge provide such ratings strongly allows for idiosyncratic and order-based biases to affect the ratings. This is particularly problematic when one considers that the drawings being rated are that of ambiguous figures, a class of stimuli that are partially defined to be perceived and recognized differently by different individuals.

In sum, the two studies described above prevent one from drawing strong conclusions pertaining to the effects of object interpretation on the appearance of drawings of ambiguous figures. Thus, the current study aims to improve on these limitations in the aim of understanding if the interpretation of what object is being depicted in an ambiguous figure affects the appearance of drawings of that figure. Here, participants completed one drawing each of two ambiguous figures: the *Gypsy/Girl with Mirror* figure (Fisher, 1967a) and the *Man/Girl* figure (Fisher, 1967b; see Figure 1). Before being exposed to an ambiguous figure, participants were randomly assigned into one of two instruction conditions that manipulated the interpretation of the figure provided to the participants; participants were either instructed to "draw the upcoming image of a man exactly as it appears" or "draw the upcoming image of a woman exactly as it appears" (see the Method section below for a more detailed and accurate description). After all of the drawings were produced, 40 independent judges were shown the entire set of drawings one at a time, and were asked to provide an *appearance rating* for each. Here, the judges provided a 0–10 rating that indicated whether the drawing appeared more like the "man" or "woman" interpretation of the ambiguous figure (represented by ratings at the poles of the scales) or whether it was unclear as to which of the two possible interpretations the drawing was emphasizing (represented by a rating of 5 on the scale).

Using this rating method, we improved on the limitations of prior research on this topic in multiple ways. First, the appearance ratings provided by judges pertained to what object the drawing seemed to be depicting, as opposed to Allen and Chambers' (2011) use of ratings pertaining to how similar or dissimilar two drawings of a single figure produced by a participant appeared to be. Thus, our rating method not only allows us to assess whether the provided interpretation affected the appearance of the drawing, but also allowed us to assess what object each drawing appeared to be depicting. Second, asking 40 judges to rate the appearance of the drawings, as opposed to only one or two, increases our ability to generate reliable inferences pertaining to the population. Also, by

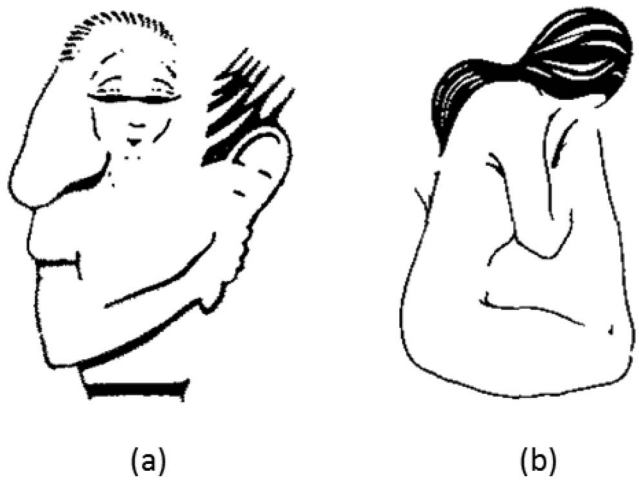

Figure 1. The two ambiguous figures that served as drawing models in this experiment. (a) *Gypsy/Girl with a Mirror* figure (Fisher, 1967a); Adapted from "Measuring ambiguity," by G. H. Fisher, 1967, *The American Journal of Psychology*, *80*, 541–557. Copyright 1967 by University of Illinois Press. (b) *Man/Girl* figure (Fisher, 1967b). Adapted from "Preparation of ambiguous stimulus materials.," by G. H. Fisher, 1967, *Perception & Psychophysics*, *2*, 421–422. Copyright 1967 by Psychonomic Society, Inc.

recruiting independent judges, as opposed to judges that were the principal authors of the study, we have eliminated the possibility of self-interest from intentionally or unintentionally influencing how the drawings were rated. Finally, as opposed to drawing conclusions about the effect of object interpretation on drawing based on the analysis of a minority of the drawings produced (as was the case in the Carmichael et al., 1932, study), the analyses and conclusions of this study were based on all drawings produced by participants (with few exceptions that are described in the Method section). This, in turn, should also serve to increase our study's ability to generate reliable inferences about the population via the reduction of sampling bias.

We tested two main hypotheses in this study. If being provided one of the possible interpretations of the ambiguous figures during task instructions biased the drawings to appear more like the provided interpretation, we would predict the following:

> *Hypothesis 1:* The mean appearance ratings should significantly differ between the drawings produced by the participants who were provided the "man" interpretation versus the drawings produced by those who were provided the "woman" interpretation.
>
> *Hypothesis 2:* The mean appearance rating of the drawings produced by participants that were provided the "man" interpretation should significantly differ from a rating of 5 in the direction on the rating-scale that indicates the drawing looks more "man-like" than "woman-like" (the opposite should be the case for the drawings produced by participants that were provided the "woman" interpretation).

The second hypothesis is as equally important to test as the first hypothesis is. Solely confirming Hypothesis 1 would be ambiguous with respect to the average appearance of a particular group's drawings (similar to the ambiguity caused by the use of *similarity ratings* in Allen & Chambers, 2011). If such a difference was found in the mean appearance ratings between the two groups receiving different interpretations, it could indicate one of three possibilities: (a) the drawings of *each* group were biased to appear, on average, more like the interpretation they were assigned to receive than the interpretation they were not assigned to receive; (b) the drawings of *both* groups were biased to appear, on average, more like the same interpretation over the other interpretation, but one group's drawings were more strongly biased in appearance than the other group's drawings were; or (c) the drawings of one group were biased to appear, on average, more like one interpretation than the other interpretation, whereas the other group's drawings were not biased at all to appear, on average, more like any of two interpretations over the other. The first possibility would be the most convincing evidence that object interpretation affects the appearance of drawings, and would be evident by observing the pattern of results described by Hypothesis 2.

Method

Participants

Ninety-six Stockton University undergraduate psychology students served as the participants who produced the drawings. However, six participants' drawings were discarded before data analysis as they produced at least one drawing that was either incomplete or judged to be a depiction not based on the stimulus (e.g., a drawing where the majority of features depicted were not derived from the features present in the model stimulus). This resulted in a final sample of 90 participants (74 females; 16 males; *M* [*SD*] age = 22.30 [5.7]).

Forty different Stockton University undergraduate psychology students served as independent judges who provided the appearance ratings for the drawings of the two ambiguous figures (34 females; six males; *M* [*SD*] age = 19.40 [2.10]).

All participants were provided course credit as compensation for participating in the study.

Materials

Ambiguous figure drawings. Each participant created one drawing each of two ambiguous figures.

One of the ambiguous figures used is commonly known as the *Gypsy/Girl with Mirror* ambiguous figure (Fisher, 1967a) and is shown in Figure 1a. In order to empirically validate the ambiguity of the figure, Fisher (1967a) showed 200 participants 15 variants of this figure that started with an image that strongly emphasized the *gypsy* interpretation (referred from here on out as the "man" interpretation) and progressively morphed into an image that ultimately and strongly emphasized the *girl with mirror* interpretation (referred from here on out as the "woman" interpretation). For each of the 15 variants, participants were asked to identify the first interpretation they perceived. The variant used in this study (Variant 7 in Fisher, 1967a) was associated with 51.50% of the participants initially perceiving the "man" interpretation and 48.50% initially perceiving the "woman" interpretation, a nonsignificant difference, $\chi^2(1) = 0.18$, $p > .05$.[1] None of the remaining 14 variants were closer to having an even split among the participants with respect to which of the two interpretations were initially perceived.

The other ambiguous figure we used is commonly known as the *Man/Girl* ambiguous figure (Fisher, 1967b) and is shown in Figure 1b. Fisher (1967b) used a similar procedure as was used in Fisher (1967a) in order to empirically validate the ambiguity of the figure, but only tested 50 participants. The variant used in this study (Variant 8 in Fisher, 1967b) was associated with 56% of the participants initially perceiving the "man" interpretation and 44% of the participants initially perceiving the "woman" interpretation, a nonsignificant difference, $\chi^2(1) = 0.72$, $p > .05$.[2] None of the remaining 14 variants were closer to having an even split among the participants with respect to which of the two interpretations were initially perceived.

The two figures were exposed to and drawn by the participants one at a time. Each figure was presented to subjects on a white background using Microsoft PowerPoint on a 19" Dell monitor. When projected onto the screen, the *Gypsy/Girl with Mirror* figure was 7.38" × 5.50" in size and the *Man/Girl* figure was 6.81" ×

[1] Fisher (1967a) did not report the results of this chi-square test. We performed this test on the data reported in Fisher's article in order to confirm that the frequency of initial interpretations did not significantly differ between the two possible interpretations.

[2] Fisher (1967b) did not report the results of this chi-square test. We performed this test on the data reported in Fisher's article for the same reason as indicated in Footnote 1.

4.06" in size. In order to produce each drawing, the participants were provided an 8.5" × 11" sheet of white paper, a No. 2 pencil with an eraser and a manual pencil sharpener.

Appearance ratings of the ambiguous figure drawings. A sample of independent judges rated the appearance of the entire set of drawings. The judges were provided two printed rating guide sheets as an aid, one for each of the two ambiguous figures (see Figure 2). Each rating guide was printed on an 8.5" × 11" sheet of white paper. On each rating guide, the ambiguous figure drawn by participants was reproduced on the top of the sheet with the following text provided underneath: "Do you think the subject was drawing the interpretation of the *man's face* or the interpretation of *the woman holding the mirror*/*the woman sitting*? Provide a 0–10 response." Below, a 0–10 number line was presented. Above the 0 and 10 points, images were displayed that depicted the most strongly emphasized version of each interpretation (Variants 1 and 15 in Fisher, 1967a, 1967b) so that the judges were clear on the two possible interpretations of each ambiguous figure. For 50% of the judges, 0–4 were the rating values used to indicate the drawing appears more like the "man" interpretation and 6–10 were the rating

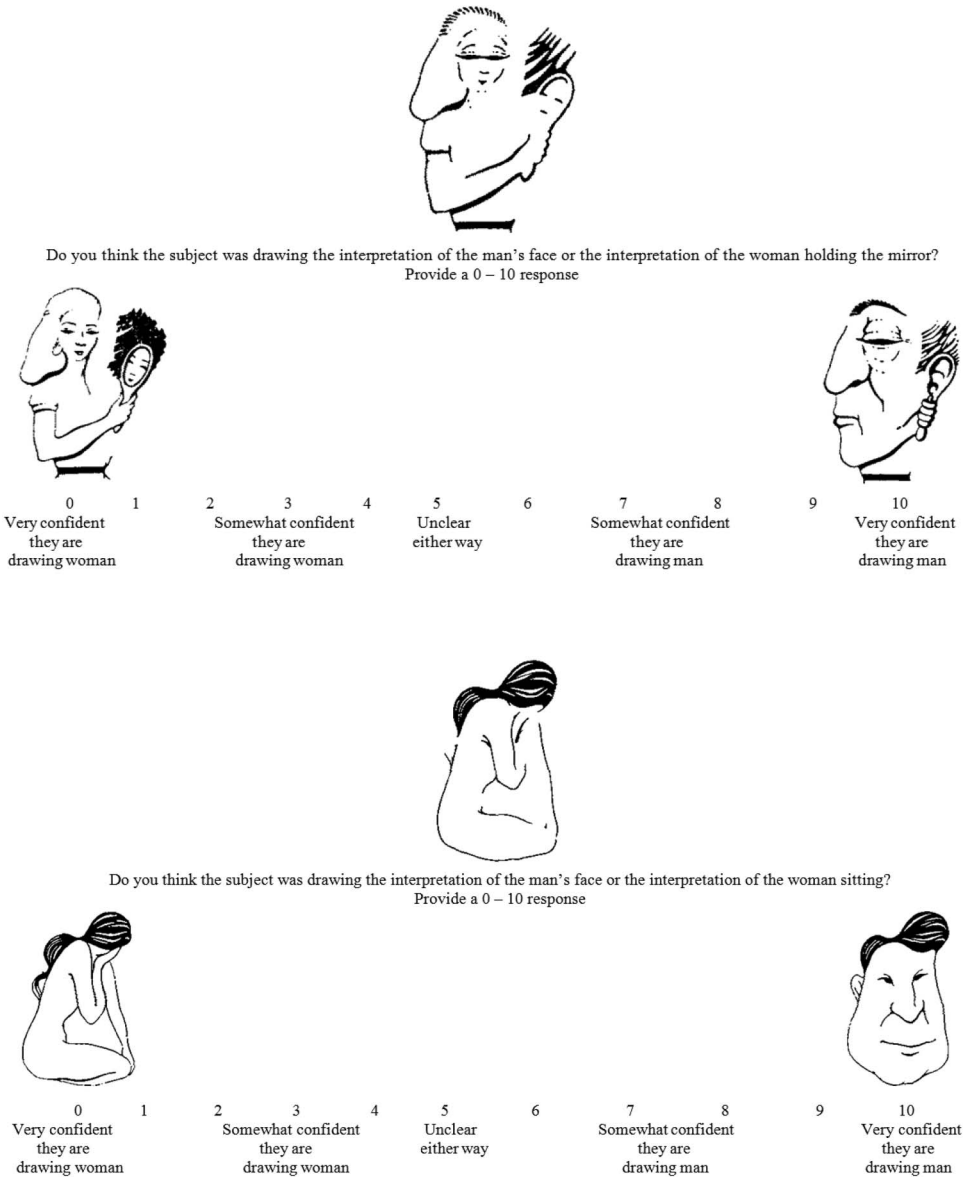

Figure 2. The guides used by judges to provide the Appearance Ratings of the drawings. In these examples, provided to 50% of the judges, 0–4 are the ratings used to indicate a more woman-like appearance and 6–10 are the ratings used to indicate a more man-like appearance. This rating system was reversed for the other 50% of judges. Images in the top guide: From *American Journal of Psychology*. Copyright 1967 by the Board of Trustees of the University of Illinois. Used with permission of the University of Illinois Press. Images in the bottom guide: Used with permission of Springer.

values used to indicate the drawing appears more like the "woman" interpretation. This was reversed for the remaining 50% of the judges.

Procedure

Drawing tasks. After providing informed consent, the participants produced drawings of the two ambiguous figures one at a time. The order of drawing the two different figures was counterbalanced across participants.

Before being exposed to *Gypsy/Girl with Mirror* figure, participants were randomly assigned to one of two instruction conditions where the provided interpretation of the figure was manipulated. For one group of participants (the Man Interpretation Group), they were told by the researcher "*In a moment, you are going to see an image of* ***a side-view of a man's face***. *Please draw this image exactly as you see it to the best of your ability*." The other group of participants (the Woman Interpretation Group) was given the same instructions, with the exception that "*a side-view of a man's face*" was replaced with "*a woman holding a mirror*." All of the participants were further instructed that they could erase and modify any aspect of their drawing during the course of its production, and that they would have a 10-min time limit to complete the drawing. Once these instructions were provided, the image of the *Gypsy/Girl with Mirror* figure was displayed, and participants began to produce their drawing.

Before presenting participants with the *Man/Girl* figure, participants were randomly assigned to one of two instruction conditions that were almost identical to those described above. The only difference was that one group of participants (the Man Interpretation Group) were told that they were going to see an image of "*a man's face*" and the other group of participants (the Woman Interpretation Group) were told that they were going to see an image of "*a woman sitting down and looking away from you.*" The remaining instructions and procedure was identical to that described in the previous paragraph.

It is important to emphasize that the interpretation provided to the participants was given before the participants were initially exposed to the ambiguous figure. The reason for this was to help prevent the participants from initially recognizing the figure as the interpretation alternative to the one they were randomly assigned to receive. It is also important to note that the participants were explicitly instructed to draw the figure exactly as it appeared. The aim of including this instruction was to reduce or eliminate any tendency of the participants to *intentionally* draw a copy of the ambiguous figure that deviated away from the exact appearance of the model.

Appearance rating task. Independent judges rated the appearance of all 180 drawings produced in the experiment. The drawings were presented one at a time as scanned images set against a white background in Microsoft PowerPoint. In a blocked-design, the judges rated all of the drawings of one ambiguous figure first, and then rated all of the drawings of the other ambiguous figure second. The order in which they rated the drawings of the *Gypsy/Girl with Mirror* and *Man/Girl* figures was counterbalanced across the judges. Within each block of drawings, each judge was provided a unique randomized order of the drawings.

The judges were provided a printed copy of the Appearance Rating Guides (described in the Materials section) when evaluating the drawings of each ambiguous figure. Before providing the ratings of the drawings of a particular ambiguous figure, the judges were given the appropriate guide and were informed that a group of participants were asked to draw the ambiguous figure that is depicted on the top of the rating guide. Then, the experimenter explained

> *Before beginning the drawing, the students were told to 'draw this image of a man's face' or were told to 'draw this image of a woman.' We want to determine if being told to draw the figure one way or another affects the appearance of the drawing. Therefore, you will view each drawing and make a judgment as to whether you think the student was drawing the man interpretation or the woman interpretation.*

The judges were instructed that they were to make their judgments using the 0–10 scale depicted on the Rating Guide. Although the judges were aware that the participants making the drawings were given one form of instruction or the other, they were blind to the instruction condition each drawing was produced under.

For each block of drawings, the judges were shown the drawings one a time, and the experimenter recorded the verbal ratings provided by the judges. Once the first block of drawings was rated, the experimenter gave the judge the Appearance Rating Guide appropriate for the other ambiguous figure drawings, reexplained the instructions, and recorded the participants' verbal ratings of the second set of drawings.

After all the ratings were collected, half of the judges' ratings were reverse-scored so that all ratings in the range of 0–4 indicated that the drawing appeared more "woman-like," and all those in the range of 6–10 indicated that the drawing appeared more "man-like."

Results

The appearance ratings of the ambiguous figure drawings were reliable across the 40 judges (*Gypsy/Girl with Mirror* figure: Cronbach's alpha = .77; *Man/Girl* figure: Cronbach's alpha = .88). Therefore, a single mean appearance rating was calculated for each individual drawing by averaging across the 40 judges' ratings.

Gypsy/Girl with Mirror Figure

As can be seen in Table 1, the mean appearance ratings of the Man Interpretation Group was significantly larger than that of the Woman Interpretation Group, indicating that the drawings produced by the Man Interpretation Group, on average, appeared more "man-like" than the drawings produced by the Woman Interpretation Group.

Upon analysis of the mean appearance ratings per group, the drawings produced by the Man Interpretation Group were biased to appear more "man-like" than "woman-like." This was confirmed by a single-sample t test whose results indicated that the mean appearance rating of this group's drawings was significantly greater than a test rating of 5.00, $t(46) = 3.07$, $p < .01$, Cohen's $d = 0.45$. In contrast, the drawings produced by the Woman Interpretation Group were, on average, biased to appear more "woman-like" than "man-like," as evident by the mean appearance rating of this group's drawings being significantly less than a test rating of 5.00, $t(42) = -3.53$, $p < .01$, Cohen's $d = 0.54$.

Table 1
Descriptive and Inferential Statistics Pertaining to the Appearance Ratings After Averaging the Individual Ratings Across All 40 Judges

Ambiguous figure	Provided interpretation group	*M* (*SE*)	95% Confidence interval of the mean	*t*	Cohen's *d*	95% Confidence Interval of difference between group means
Gypsy/Woman	Man	5.71 (.23)	[5.26, 6.16]	4.70*	.99	[.96, 2.36]
	Woman	4.05 (.27)	[3.52, 4.58]			
Man/Girl	Man	6.43 (.15)	[6.13, 6.73]	3.80*	.81	[.50, 1.59]
	Woman	5.38 (.23)	[4.94, 5.84]			

Note. Ratings falling within the range of 0–4 indicate a more woman-like than man-like appearance. Ratings falling within the range of 6–10 indicate a more man-like than woman-like appearance. The *t* statistic is the result of an independent samples t-test comparing the mean appearance ratings between the two interpretation groups (df = 88). Two of such *t*-tests were performed, one for each of the two ambiguous figures.
* $p < .001$.

Man/Girl Figure

As shown in Table 1, the mean appearance ratings of the Man Interpretation Group was significantly larger than that of the Woman Interpretation Group. As with the *Gypsy/Girl with Mirror* figure drawings, this indicates that participants in the Man Interpretation Group produced drawings that appeared more "man-like," on average, than the participants in the Woman Interpretation Group.

Upon analysis of the mean appearance ratings per group, the drawings produced by the Man Interpretation Group were biased to appear more "man-like" than "woman-like," as evident by the mean appearance rating of this group's drawings being significantly greater than a test rating of 5.00, $t(45) = 9.37$, $p < .001$, Cohen's $d = 1.38$. However, the drawings produced by the Woman Interpretation Group were not biased to appear, on average, more "woman-like" or "man-like," as indicated by the mean appearance rating of this group's drawings being nonsignificantly different from a test rating of 5.00, $t(43) = 1.67$, $p > .05$, Cohen's $d = 0.25$.

Discussion

The results reported above provide stronger evidence than what has been reported in the past that individuals' interpretation of what object a model depicts affects the appearance of the drawings they produce. To recap, drawings produced by participants that differed with respect to the interpretation of the ambiguous figures they were provided in the task instructions were rated, on average, to have significantly different appearances. This is consistent with Allen and Chambers' (2011) report that the appearance of nonautistic adolescents' drawings of ambiguous figures are affected when task instructions provide an interpretation describing one of the possible interpretations of the figure. Further, our study, unlike the study reported by Allen and Chambers (2011), specifically analyzed the nature of the differences in the drawings' appearance that was caused by the interpretations of the ambiguous figures. Consistent with the results reported by Carmichael et al. (1932), we observed, for the most part, that the drawings were systematically biased, on average, to appear more like the object that was the subject of the interpretation provided in the task instructions than the alternative interpretation of the figure that was not described in the task instructions. This was found by analyzing the ratings of all drawings that were provided by independent judges, as opposed to being found by analyzing the ratings of only a minority of the drawings provided by the nonindependent authors of the study (as was the case in the study of Carmichael et al., 1932).

However, there was one exception to the idea that the drawings were biased to appear more like the interpretation provided in the task instructions than the interpretation not provided in the instructions. With respect to the drawings of the *Man/Girl* figure, participants provided the "man" interpretation produced drawings that were significantly biased, on average, to appear more "man-like" than "woman-like." In contrast, the drawings produced by participants provided the "woman" interpretation were not significantly biased to appear more "man-like" or "woman-like." Rather, the mean appearance rating of the drawings produced by this group did not significantly differ from a rating of 5, which is the rating representing ambiguity with respect to the object being depicted in the drawings. Because the appearance ratings of the drawings produced by the "woman" interpretation group had an approximate normal distribution with a central tendency that was not significantly different from 5, it may be that the "woman" interpretation provided in the task instructions was simply not sufficient to cause most drawings produced by this group to considerably deviate from the ambiguous appearance from the model. This explanation assumes that the participants were not affected by the "woman" interpretation provided to them. Alternatively, many of the participants producing the drawings may have been biased to more easily perceive the "man" interpretation than the "woman" interpretation, even if the participants were provided the "woman" interpretation in the task instructions. If so, the "woman" interpretation provided to participants may have affected the appearance of their drawings by reducing or eliminating this "man" bias.

With the current data set, it is impossible to discriminate between these possibilities due to an important limitation of our method. Namely, we did not include a control condition where participants drew the ambiguous figures without being provided an interpretation in the task instructions. If we had, we may have been able to determine if the participants producing the drawings had a baseline bias to produce drawings that appeared more like one interpretation or the other. Such a condition would have provided data that could inform whether the "woman" interpretation had no effect on the appearance of drawings versus whether it had an effect to reduce a possible "man" bias. Nevertheless, a control condition was not necessary to provide a basic demonstration that object interpretation affects the appearance of ambiguous figure

drawings, as the difference in mean appearance ratings between the groups that were provided different interpretations in the task instructions indicates that at least one of the groups' drawings were affected by the manipulated interpretation of the figure.

Mechanisms Producing the Effects of Interpretation on the Appearance of Ambiguous Figure Drawings

Although our study provides evidence that the appearance of drawings of an ambiguous figure is affected by how the figure is interpreted, it is presently unknown what psychological mechanisms produce this effect. Although our method does not allow for an understanding of the relevant mechanism(s), we can offer some tentative explanations. One possibility may relate to the decision-making processes related to an individual's selection of what object-features to emphasize and de-emphasize in a depiction (Biederman & Kim, 2008; Kozbelt et al., 2010; Kozbelt, Snodgrass, & Ostrofsky, 2014; Ostrofsky, Kozbelt, & Seidel, 2012). Because the two interpretations of a single ambiguous figure differ in their diagnostic, defining features, individuals differing in their interpretation of the figure may differentially attend to, emphasize, and/or elaborate on some features over others in their drawings. For instance, with respect to the *Gypsy/Girl with Mirror* figure, individuals perceiving the "woman" interpretation may decide to emphasize and/or elaborate on the facial features of the girl while those perceiving the "man" interpretation may decide to de-emphasize these facial features (as evident by the representative examples found in Figure 3). With respect to the *Man/Girl* figure, individuals perceiving the "woman" interpretation may decide to emphasize the rounded shape of the woman's head, whereas those perceiving the "man" interpretation may decide to de-emphasize this round shape when depicting the man's hair (as evident by the representative examples found in Figure 4).

Another possible mechanism that could explain how the interpretation of an ambiguous figure affects how drawings of them appear could be related to the influence of schematic graphic symbols stored in long-term memory. Researchers have theorized that, through development, individuals acquire schematic graphic symbols that are habitually used to refer to, or "stand-for," the objects and/or features of the objects they are trying to depict (Cohn, 2012; Edwards, 2012). Simple examples of this include using a stick figure to depict a human body, using a U-shape to depict a smiling mouth, and using a football shape with embedded circles and/or dots to depict an eye. While such schematic graphic symbols are successfully interpreted to represent the intended object, demonstrating their communicative utility, they are not successful in depicting the appearance of specific, individual objects perceived from a particular view-point.

While such graphic symbols may be most heavily used when drawing from memory without the guide of a model, prior research has suggested that graphic representations stored in long-term memory are activated and influence the production of observational drawings in addition to the bottom-up processing of the specific visual appearance of the model (Matthews & Adams, 2008; Ostrofsky, 2015). Thus, features depicted in an observational drawing of an ambiguous figure, as with other model objects, may deviate away from the appearance of the model toward the appearance of the graphic, symbolic representation of those features that are stored in long-term memory. Because the different interpretations of an ambiguous figure vary with respect to the important features that define each possible object, one could hypothesize that being provided different interpretations of an ambiguous figure activate different graphic schemas that guide drawing production, causing the differences in drawing appearance between those interpreting the figure differently. For example, in the *Gypsy/Girl with Mirror* figure, a single region could be interpreted as a full face (in the "woman" interpretation) or as a single, closed eye (in the "man" interpretation). Being provided the "woman" interpretation in the task instructions could have acti-

Figure 3. Examples of drawings of the *Gypsy/Girl with Mirror* ambiguous figure. Drawings in the top row were produced by individuals who received the "man" interpretation; drawings in the bottom row were produced by individuals who received the "woman" interpretation. Permission to reproduce the drawings was granted by participants during the informed consent process.

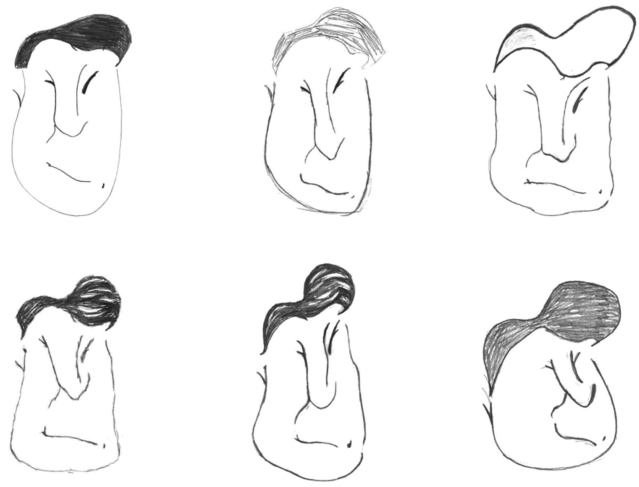

Figure 4. Examples of drawings of the *Man/Girl* ambiguous figure. Drawings in the top row were produced by individuals who received the "man" interpretation; drawings in the bottom row were produced by individuals who received the "woman" interpretation. Permission to reproduce the drawings was granted by participants during the informed consent process.

vated a graphic schema that represents how to draw a face whereas being provided the "man" interpretation could have activated a graphic schema that represents how to draw a closed eye. One could speculate similar differences in activated schemas could exist for the ear/mirror, mouth/arm, and nose/hair regions. Differences in the appearance of the drawings would be predicted if such differential schemas were activated and influenced the production of drawings beyond the visual appearance of the ambiguous figure itself.

Rather than conceiving of these two proposed mechanisms as competing explanations, the activation of graphic schemas and decision-making/visual selection processes may act in concert with one another to produce the effects we observed in this study. Kozbelt and Seeley (2007) theorized that the activation of graphic schemas guide individuals' visual selection of features to be included and/or emphasized in a given depiction of a model. Thus, being provided different interpretations of an ambiguous figure may activate different graphic schemas, which then might cause different features of the model to be visually selected and emphasized in a drawing, causing the variability in appearance of the drawings that were based on different interpretations of the figures.

A final possible explanation of our findings to be discussed here is that the drawings of the different interpretation groups appeared as different objects due to demand characteristics. In other words, when provided the "man" or "woman" interpretation, participants may have intentionally produced a drawing that deviated from the appearance of the model in order to create a drawing that looked more like the instructed interpretation than the model. Although we cannot rule out this possibility, we would like reiterate that we explicitly attempted to reduce the chances of this occurring by emphasizing in the task instructions that the participants' goal was to draw the figure exactly as it appeared.

Conclusion

To conclude, we provide evidence that the interpretation of an ambiguous figure affects the appearance of drawings based on them, mostly in congruence with the object the figure is interpreted to depict. Thus, the addition of our results into the research literature on this topic leads to the conclusion that categorization of model objects affects both the sequential process of producing a drawing (Van Sommers, 1984; Vinter, 1999) and the drawing's ultimate appearance. Although our study does not allow for strong conclusions as to how object interpretation specifically affects drawing performance, we argue that the continued study of ambiguous figure drawings may be a useful tool for future research that aims to more fully understand how the categorization of object identity affects drawing performance. Most generally, these results add to the growing body of evidence that demonstrates observational drawing performance is not a behavior that is exclusively guided by the bottom-up perceptual encoding (or misencoding) of visual information apparent in a model, but rather involves top-down influences of attention, decision-making, long-term memory, and/or object categorization processes.

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